Staff Report of the

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

WATER QUALITY OF THE LOWER SAN JOAQUIN RIVER: LANDER AVENUE TO VERNALIS OCTOBER 1997 - SEPTEMBER 1998

(WATER YEAR 1998)

MAY 2000

State of California

California Environmental Protection Agency

REGIONAL WATER QUALITY CONTROL BOARD
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THIS REPORT WAS CONSIDERED AND APPROVED BY THE CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD ON 28 APRIL 2000

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Many thanks to the staff and students of the Agricultural Unit without whose efforts during field sampling, quality control, and data processing, this report would not have been possible.

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EXECUTIVE SUMMARY

Since May 1985, the Central Valley Regional Water Quality Control Board has conducted a water quality monitoring program on the lower San Joaquin River to evaluate the effects of subsurface agricultural drainage inflows. The study area consists of the 60-mile section of the San Joaquin River extending from Lander Avenue near Stevinson to Airport Way near Vernalis. Five major tributaries flow into the river within this study area: Salt Slough, Mud Slough (north), and the Merced, Tuolumne, and Stanislaus Rivers. Salt Slough and Mud Slough (north) drain the Grassland Watershed of western Merced County and are the major source of agricultural subsurface drainage water discharges to the river system. The Merced, Tuolumne, and Stanislaus Rivers are east side streams which drain the Sierra Nevada and provide high quality dilution flows.

The period covered by this report, 1 October 1997 through 30 September 1998 (Water Year 1998[1]), represents the second year of the operation of the Grassland Bypass Project. The project began operation on 23 September 1996 and consolidated subsurface agricultural drainage, which historically flowed through wetland habitat, into a single channel, allowing the drainage to bypass approximately 90 miles of wetland water supply channels and Salt Slough. The drainage was redirected into the lower nine miles of Mud Slough and eventually into the San Joaquin River.

During Water Year 1998, water quality information was collected at eight sites along the river, representing both background water quality and influences of major inflows. The primary constituents evaluated included electrical conductivity, boron and selenium, with more limited analyses of molybdenum, copper, chromium, lead, nickel, zinc, chloride and sulfate. Grab samples were collected on a weekly, monthly or quarterly schedule depending on the location. Automated, composite samples were also collected at Crows Landing site and, between April and August, at the Patterson site, to provide information on fluctuating concentrations and to provide a more complete data set for calculation of salt, boron, and selenium loads.

The San Joaquin River Index is used to classify water year type in the river basin based on total runoff (SWRCB, 1997). Water Year 1998, was classified as a wet water year with periods of localized flooding occurring in February and March and elevated river levels continuing into July. Statewide, twice the normal precipitation occurred during January and over three times the normal occurred in February. The localized flooding resulted in the diversions of commingled agricultural subsurface and storm drainage flows from the Drainage Project Area into both Mud Slough (north) and Salt Slough between 3 and 28 February, with ultimate discharge into the San Joaquin River. The elevated flows from the Grassland Watershed continued into June 1998. Flood conditions along the Lower San Joaquin River during these time periods resulted in limited water quality data at a number of sites.

During Water Year 1998, constituent concentrations followed trends observed during the previous years of study. The highest concentrations occurred downstream of Mud Slough (north) which carries the discharges from the Grassland Bypass Channel, while the lowest concentrations were recorded at the background (Lander Avenue) site and downstream of the

[1] A Water Year covers the time period from 1 October through 30 September of the following year.

eastside tributary dilution flows, at Vernalis. During Water Year 1998, mean concentrations of EC, boron and selenium were lower at all sites, as compared to previous wet or critically dry water years. The improvement in overall water quality is likely due in great part to the elevated dilution flows from Friant Dam and the eastside tributaries that occurred between February and July 1998. Maximum salt concentrations were elevated over concentration noted during wet Water Year 1997, with high concentrations occurring just prior to the February storms, while maximum selenium concentrations were substantially less than those recorded during Water Year 1997.

In October 1988, the Regional Board adopted water quality objectives for boron, molybdenum and selenium for the lower San Joaquin River between Sack Dam and Vernalis. Two sets of objectives were developed. One set of objectives was established for the river reach with minimal freshwater flow (between Sack Dam and the mouth of the Merced River) and the second set was for the reach of river with highly managed freshwater flows (from the mouth of the Merced River to Vernalis). The boron objective is also based on season, with more stringent objectives applying during the irrigation season (March 15 through September 15) when downstream crops would be susceptible to boron toxicity from irrigation water. In May 1996, the Regional Board adopted revised selenium water quality objectives for the lower San Joaquin River along with a compliance time schedule. Final approval of the revised objectives and compliance time schedule was received on 10 January 1997. The selenium compliance time schedule does not require full compliance with the selenium objective until 1 October 2005 or 1 October 2010, depending on which reach of the river is being evaluated and the classification of the water year.

During Water Year 1998, the applicable monthly mean boron objectives were not exceeded in the Lower San Joaquin River based on weekly grab samples. Review of the daily composited data from the Crows Landing and Patterson sites also indicated no exceedances. The instantaneous maximum boron water quality objectives (2.0 mg/L to 5.8 mg/L, depending on the river location and time of year) were not exceeded during Water Year 1998. The highest boron concentration recorded was 1.9 mg/L at Hills Ferry during early January 1998.

During Water Year 1998, the selenium objective of 5 µg/L (based on a 4-day average and subject to a compliance time schedule), was not exceeded at any of the sites downstream of the Merced River. However, several of the weekly grab samples collected at the Hills Ferry site contained over 5 ug/L selenium. The monthly mean concentration at the Hills Ferry site exceeded 5 µg/L, during October 1997. The maximum selenium water quality objectives which applied, 12 µg/L to 20 µg/L, depending on location, were not exceeded at any time during Water Year 1998. The highest selenium concentration recorded in the river was 7.8 µg/L at Hills Ferry on 9 October 1997.

The molybdenum water quality objectives were met at all sites monitored. The highest molybdenum concentration detected in the San Joaquin River during the study period, was 11 µg/L at the Hills Ferry site on 30 October 1997 and again on 26 December 1997. The reported maximum concentration does not exceed any of the adopted continuous or maximum molybdenum water quality objectives.

Salt, boron, and selenium loads for the San Joaquin River at Crows Landing and the San Joaquin River near Vernalis were estimated based on the flow weighted monthly average of available water quality data for Water Year 1998. Discharge data for the Vernalis site was based upon US Geological Survey (USGS) reported daily discharges. USGS discharge data for the Crows Landing site was evaluated and replaced with the summed discharge of upstream sites for January through July 1998 because the reported USGS discharges could not be reconciled with discharge data for San Joaquin River sites upstream and downstream of Crows Landing. Evaluation of the discharge data is presented in Appendix D.

High rainfall and snowmelt from February through July resulted in extremely high discharge for both river sites. Loads of salt and boron peaked for both sites in February and March. Selenium loads remained above 2,000 pounds per month from February through May at Crows Landing, with a peak monthly load of 2,510 pounds in March. The peak monthly selenium load near Vernalis was 3,370 pounds during March, with loads above 2,000 pounds from February through May. The total selenium loads calculated for the two sites during Water Year 1998 were 13,445 pounds at Crows Landing and 15,810 pounds at Vernalis.

During Water Year 1998, tile drainage discharged from the Drainage Project Area via the Grassland Bypass project, accounted for 1 percent of the flow, 13 percent of the salt load, 34 percent of the boron load, and 65 percent of the selenium load in the San Joaquin River at Crows Landing. This tile drainage accounted for less than 1 percent of the flow, 8 percent of the salt load, 25 percent of the boron load, and 55 percent of the selenium load at Vernalis. More information on the Drainage Project Area discharges during Water Year 1998, can be found in a companion report (Chilcott, 1999a).

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INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program on the lower San Joaquin River in May 1985 to evaluate the effects of subsurface agricultural drainage inflows. Water quality samples have been collected at eight monitoring sites along a 60-mile section of the River, extending from near Stevinson in Merced County to Airport Way near Vernalis in San Joaquin County, since the beginning of the program. This monitoring program has provided an on-going database for selected inorganic constituents found in San Joaquin River water. The database is used to assess the immediate effects of agricultural drainage water on the quality of the San Joaquin River, as well as the long-term effects of regional agricultural drainage reduction programs on overall river water quality.

This report contains laboratory results and a summary of water quality analyses for all constituents measured as part of the program during Water Year 1998 (October 1997 through September 1998).[2] Water Year 1998 represents conditions during the second year of operation of the Grassland Bypass Project. The Grassland Bypass began operation on 23 September 1996 and consolidated subsurface agricultural drainage, which historically flowed through wetland water supply channels, into a single channel that discharges to Mud Slough (north), allowing the drainage to bypass approximately 90 miles of wetland water supply channels. Water quality information collected as part of this multi-agency project is available on the U.S. Bureau of Reclamation's Grassland Bypass Project web page at:

www.mp.usbr.gov/mp150/grassland/HomePage/Homepage.html

This report presents the data collected during the second year of operation, and compares salinity (measured as electrical conductivity), boron and selenium water quality at selected sites on the San Joaquin River, upstream and downstream of the Mud Slough (north) inflow, with respect to hydrology, change in water management, and applicable water quality objectives.

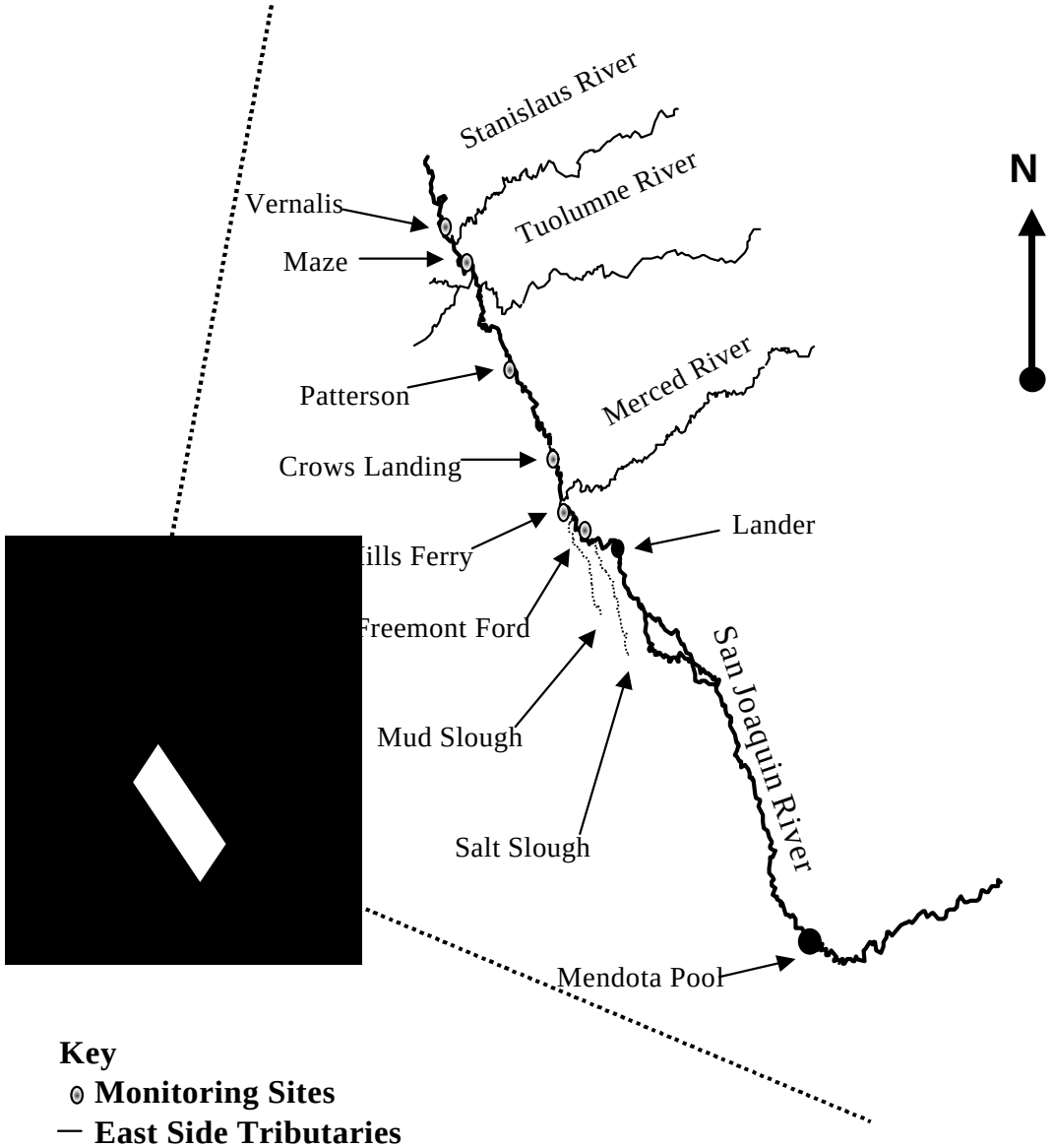
Water quality data collected during the previous years of study can be found in both a summary report presenting salinity, boron, and selenium information from May 1985 through September 1996 (Steensen et al., 1998) and in a series of annual reports presenting all water quality information collected through September 1997 (James, *et al*., 1988; Westcot, *et al*., 1989a, 1990, 1991, and 1992, Karkoski and Tucker, 1993; Chilcott, *et al.*, 1995; Steensen *et al.*, 1996; and Chilcott *et al*., 1998a). This monitoring program was designed to complement monitoring programs conducted by other state, federal, and local agencies.

STUDY AREA

The study area consists of the 60-mile section of the San Joaquin River extending from Lander Avenue (Highway 165) near Stevinson to Airport Way near Vernalis. Monitoring sites are located near seven of the eight river overcrossings on this section of the River (Figure 1).

[2] A water year lasts from October 1st of one year through September 30th of the following year.

Figure 1. Monitoring Locations Along the Lower San Joaquin River.



Five major tributaries flow into the San Joaquin River within this study area: Salt Slough, Mud Slough (north), and the Merced, Tuolumne, and Stanislaus Rivers. Salt Slough and Mud Slough (north) drain the Grassland Watershed of western Merced County and discharge to the San Joaquin River in the southern portion of the study area (Figure 1). These two sloughs carry a varying mixture of surface and subsurface agricultural drainage, operational spillage from irrigation canals, and drainage from duck ponds flooded for waterfowl habitat. The Merced, Tuolumne, and Stanislaus Rivers are east side streams which drain the Sierra Nevada. All three streams receive some agricultural return flows in their lower reaches upstream of the San Joaquin River; however, overall water quality remains relatively high.

The Hills Ferry Road site was initiated in order to measure water quality in the San Joaquin River downstream of inflows from the Grassland Watershed and upstream of inflows from eastside tributaries. Aerial surveillance and ground truthing conducted toward the end of Water Year 1998 indicated that a portion of the Merced River discharges upstream of the sampling site during some flow regimes. Reevaluation of the sampling location is being conducted.

In addition to the five major tributaries, there are also a number of smaller tributaries, as well as surface and subsurface agricultural drains, that discharge to the San Joaquin River within the study area. All significant inflows and their locations, including the monitoring sites, are referenced by river mile and listed in Table 1. A full description of the inflow points that occur in this 60-mile section of the river is in James, *et al*. (1989).

Prior to October 1996, subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tail water) from the Grassland Watershed was discharged to the San Joaquin River through Salt Slough and/or Mud Slough (north). These two sloughs are tributary to the San Joaquin River and serve as the drainage outlets for the Grassland Watershed with Salt Slough carrying the bulk of the subsurface agricultural drainage from Water Year 1989 through Water Year 1996 (Steensen, et al., 1998 and Chilcott, et al., 1998b).

After October 1996, all subsurface agricultural drainage from a 97,000 acre area within the Grassland Watershed known as the Drainage Project Area (DPA), was rerouted into the Grassland Bypass which discharges into the final 28 miles of the San Luis Drain. The consolidated subsurface drainage is then released into Mud Slough (north), nine miles upstream of its confluence with the San Joaquin River. Consolidating the subsurface drainage removed the primary source of selenium in approximately 90 miles of canals within the Grassland Watershed which can supply water to wetland habitat, and also removed this drainage from Salt Slough. Reducing selenium in these water bodies is a primary goal of the project, since elevated concentrations of selenium have been documented to impact waterfowl (Skorupa, 1998).

A small number of subsurface agricultural drainage systems to the east and west of the Grassland Water District continue to discharge into local drainage courses that enter the wetland area. Evaluation of these discharges is being conducted by local water agencies and Regional Board staff with findings outlined in a separate report (Chilcott, 2000b).

Table 1. Tributaries and Drains to the San Joaquin River Between Monitoring Stations from the Lander Avenue Bridge to Vernalis (James et al., 1989)

River Mile	Description	Water Make-up	Sampling Period of Record
132.9	**Lander Avenue**	R	85-98
129.7	Salt Slough	T,S	85-98
125.1	**Freemont Ford**	R	85-98
121.2	Mud Slough	T,S	85-98
119.6	Newman Wasteway	O,S	
119.5	Newman Drainage District Collector Line A	T	
119.1	Hills Ferry Road Drain	S	
118.8	**Hills Ferry Road**	R	85-98
118.2	Merced River	N	98-
117.5	Newman Drainage District Lateral Line 1	T	
117.2	Azevedo Road Drain	S	
113.4	Frietas Road Drain and South of Frietas Road Drain	S	
112	Turlock Irrigation District Lateral 6	S,O	
109	Orestimba Creek	N,S	94
107.2	**Crows Landing Road**	R	85-98
105	Spanish Grant, Marshall Road, Moran Road Drain	S,T	
103.5	Turlock Irrigation District Lateral 5	S	
100	Ramona Lake Main Drain	S,T	
98.6	Patterson Water District Main Drain	S,T	
98.4	**Patterson: Las Palmas Launching Facility**	R	85-98
97.6	Olive Avenue Drain	S	
97.3	Lemon Avenue Drain	S	
97	Eucalyptus Avenue Drain	S	
95.2	Turlock Irrigation District Lateral 3	S	
92.9	Del Puerto Creek	N,S	
91.4	Houk Ranch Drain	S,T	
90.3	Turlock Irrigation Lateral 4	S	
89.1	**Grayson Road ***	R	85-92
87	Old San Joaquin River Channel	S	
83.7	Tuolumne River	N	98-
81.1	Merced Irrigation District Lateral 4	S	
79.9	Hospital/Ingram Creeks	S,T	
78.9	Center Road Drain	S	
77.6	Blewett Drain	S,T	
77.4	Blewett Drain	S	
77.3	**Maze Boulevard**	R	85-98
74.9	Stanislaus River	N	98-
73.6	**Vernalis (Airport Way)**	R	85-98

LEGEND

R San Joaquin River Water
S Surface Agriculture Drain
T Subsurface Agriculture Drain
N Natural Stream
O Operation Spillage

* Deleted from monitoring program after WY93

Stations shown in BOLD type are part of the monitoring program

Table 2. Monitoring Sites, Sampling Frequencies, and Parameters Measured in the San Joaquin River: Water Year 1998

Site ID	Site Description	Constituents									Diss. Se	TSS	Auto-Samplers
		Temp	pH	EC	Se	Mo	TE's	B	FM	PM			
San Joaquin River at:													
MER522	Lander Avenue	W	W	W	M	Q	Q	Q		Q		W	
MER538	Fremont Ford	W	W	W	W			W		Q			
STC512	Hills Ferry	W	W	W	W	Q	Q	W	Q			W	
STC504	Crows Landing	W	W	W	W	Q	Q	W		Q	W	W	a
STC507	Patterson	W	W	W	W			W		Q		W	a*
STC510	Maze	W	W	W	W			W		Q			
SJC501	Vernalis	W	W	W	W	Q	Q	W	Q			W	
MER546	Merced River	Q	Q	Q	Q		Q	Q		Q			
STC513	Tuolumne River	Q	Q	Q	Q		Q	Q		Q			
STC514	Stanislaus River	Q	Q	Q	Q		Q	Q		Q			

W = weekly
M = monthly
Q = quarterly (Oct, Jan, Apr, and Jul)
a = daily composite sample for EC, Se and B
a*= daily composite sample for EC, Se and B collected between 10 April and 6 August
FM: B, Cl, SO4, CO3, HCO3, Alkalinity, Ca, Mg, Na, TDS, K, Hardness

Temp: temperature
EC: electrical conductivity
Se: selenium

TE's: total Cr, Cu, Pb, Ni, Zn
Mo: molybdenum
PM: B, Cl, SO4, and Hardness
TSS: total suspended solids

SAMPLING PROGRAM

The Regional Board monitoring program for the San Joaquin River began in May of 1985 and has continued through Water Year 1998 (WY98). Grab samples were collected at seven of the eight original sites during WY98. The eighth site, the San Joaquin River at Grayson Road, was deleted from the program after December 1992. Water temperature, pH, electrical conductivity (EC), and sample time were recorded in the field at each site. Laboratory analyses for total recoverable selenium, boron, and EC were performed on all samples weekly, except at the San Joaquin River at Lander Avenue site where samples were analyzed for selenium and boron quarterly. Samples from all sites were analyzed for chloride, sulfate and hardness on a quarterly basis. Samples from selected sites were also analyzed for total recoverable molybdenum, copper, chromium, lead, nickel and zinc on a quarterly basis. Samples from the Crows Landing and Vernalis sites were analyzed quarterly for an additional suite of minerals. The primary focus of the program, however, remains on electrical conductivity, boron and selenium.

A continuous automated sampler was employed at the Crows Landing site during WY98. The autosampler collected daily composite samples near mid-channel for electrical conductivity, boron and selenium analyses. Location of the autosampler on a floating dock made access difficult to impossible during some flood events and extended the period of time between servicing from two weeks to approximately six weeks. An additional autosampler was installed downstream of Crows Landing at the Patterson site between 10 April and 6 August 1998. The Patterson site is more accessible during flood conditions than the Crows Landing site. A comparison of the two data sets is presented later in this report.

A summary of the sites and frequency of constituent monitoring is listed in Table 2.

SAMPLE COLLECTION METHODS

Two distinct types of water samples were collected for this program: grab samples and automated composite samples. The types of samples, methods for collection and quality control and assurance are discussed below.

Grab Samples

During WY98, grab samples were collected on either a weekly, monthly or quarterly basis depending on the site and the constituent to be analyzed (Table 2). Field measurements for water temperature, electrical conductivity (EC), and pH were conducted at all sites. Follow up EC measurements were made on all samples at the Regional Board office laboratory within 24 hours of sample collection by Regional Board staff. Analyses for EC, total boron, and total selenium were conducted on all samples. Selected sites were also monitored for molybdenum, copper, chromium, nickel, lead, and zinc on a monthly or quarterly basis. A weekly sample collected at the Crows Landing site was also analyzed for dissolved selenium.

Grab samples were collected in polyethylene bottles, usually within six feet of the bank. All sample bottles were rinsed with deionized water before use. All bottles were also rinsed three times with the water to be sampled prior to sample collection. All samples were kept on ice after collection and until processing. Selenium, boron, and trace element samples were preserved by lowering the pH to less than 2 within 24 hours of collection, using reagent grade nitric acid. Mineral samples were kept on ice until submittal to the laboratory for analysis. Additional quality assurance and control procedures are discussed in a later section.

Composite Automated Samples

In addition to grab samples, daily composite sampling was conducted on the San Joaquin River at Crows Landing and for a brief period on the San Joaquin River at Patterson, through the use of an automated Sigma sampling device. Each daily composite is made up of two 250 ml collections pulled at 12-hour intervals for a total sample volume of 500 ml. During WY98, the autosampler was serviced every two weeks except during an extended period of high water levels in the river which stranded the Sigma unit mid-stream on a floating dock. During that time period (4 February through 31 July 1998), two Sigmas were installed on the dock and were accessed by boat and serviced approximately every six weeks.

Due to the accessibility problems with the Crows Landing Sigma, a backup Sigma was installed at the Patterson site. The Patterson Sigma was in operation between 10 April and 6 August 1998 and serviced every two weeks.

All samples collected by Sigmas were analyzed for EC, boron and selenium. Quality control and assurance methods for the autosampling are discussed below.

QUALITY CONTROL AND QUALITY ASSURANCE

Potential contamination from the reagent grade nitric acid used to control pH was evaluated by submitting a deionized water matrix preserved with the standard amount of acid used (1 ml of acid for each 500 ml of sample), to the analyzing laboratories at monthly intervals to be analyzed for the trace elements of concern. All reported recoveries for these acid check samples were below the analytical detection limit.

Field and handling contamination was evaluated by submitting a travel blank on a monthly basis. The travel blank consisted of a sample of deionized water which was collected at the Regional Board laboratory, traveled through the sampling run, and was then processed with the sample set. All results for travel blanks fell below the analytical detection limits for the elements of concern.

Additional quality control and quality assurance was conducted using blind split and spiked samples. Blind split samples were collected at a ten percent frequency for each sampling event by collecting the sample in a container double the normal sample volume and splitting that sample into two equal amounts for submittal to the analyzing laboratory. On a monthly basis, half of the blind split samples were spiked with known concentrations of constituents to be analyzed. Comparing the spiked splits to the background splits provided information on analytical accuracy. Comparing data from nonspiked splits provided information on analytical precision.

To evaluate the potential for contamination and evapo-concentration in samples collected using autosamplers, a series of special checks were developed. First, whenever the sampler was serviced, a deionized water sample, without a cap, was left in the collection base to be collected on the next servicing and analyzed for potential contamination. Second, during each servicing, replicate "grab" samples were collected through the autosampler mechanism, one was left in the sampler to be collected at the next servicing and the other was processed for immediate analyses. Final results of the two grabs were evaluated to determine concentration or dilution potentials.

During WY98, samples for dissolved selenium were collected from the San Joaquin River at the Crows Landing site. These samples required field filtration through a 0.45 micron cartridge system. To prevent and evaluate potential contamination, the equipment was soaked in a two percent nitric acid solution for a minimum of two hours, and rinsed three times in DI water. The new filters were conditioned at the time of sampling by allowing the first 10 ml of water passed through to be discarded before the remaining sample was collected. Approximately quarterly, filter blanks were collected by processing Regional Board laboratory DI water through the standard equipment used in the field.

Only data from sample sets whose blind QA/QC met specifications outlined in Table 3 have been included in this report.

Table 3. Quality Assurance Tolerance Guidelines Used in the Regional Water Quality Control Board Agricultural Drainage Monitoring Program.

Constituent	Recovery Range at Low Levels (µg/L)*	Acceptable Split/Spike Recovery Range
Copper	1-20 ± 5	>20 70-130%
Chromium	1-20 ± 5	>20 70-130%
Lead	5-25 ± 8	>25 60-140%
Molybdenum	1-10 ± 2	>10 85-115%
Nickel	5-25 ± 6	>25 65-135%
Selenium	0.4-10 ± 0.8	>10 90-110%
Zinc	1-20 ± 6	>20 70-130%
Boron	50	85-115%
Chloride	5000	85-115%

* For certain constituents, recovery is expressed as an absolute value rather than a percentage at low levels. For example, if the result of copper analysis for a particular sample is 10 µg/L, a split analysis must fall between 5 µg/L and 15 µg/L. If the sample is greater than 20 µg/L, recovery is expressed as a percent and must be between 70 and 130%. If a recovery range is not shown at low levels, the detection limit is given.

RAINFALL AND DISCHARGE PATTERNS

The San Joaquin River Index, as described in the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB, 1995) is used to classify the water year type in the river basin based on runoff. The 60-20-20 Index includes one "wet" classification, two "normal" classifications (above and below normal), and two "dry" classifications (dry and critical), for a total of five water year types. Water year 1998 was classified as "wet" based on runoff exceeding 3.8 million-acre feet.

Friant Dam essentially serves as the headwaters of the lower San Joaquin River. The majority of water from Friant Dam is diverted into the Friant-Kern Canal for use in agricultural irrigation outside of the San Joaquin River Basin. Historically, the only releases which reach the Lower San Joaquin River (Mendota Pool and downstream) are during flood events and high flows from winter snow melt. WY98 was an unusual flow year due to extremely high rainfall during January and February and storms that continued into June. A comparison of rainfall at and discharge from Friant Dam into the San Joaquin River for WY98 is depicted in Figure 2. During WY98, early rainfall events had little if any effect on the releases from Friant Dam, indicating the highly managed nature of the San Joaquin River hydrology. However, after January, releases to the San Joaquin River from Friant occurred and continued through 29 July 1998.

Rainfall at the CIMIS (California Irrigation Management Information System) Station #124 at Kesterson National Wildlife Refuge and flows in the San Joaquin River at Lander Avenue, Patterson, and Vernalis, a series of sites moving downstream to the Sacramento-San Joaquin Delta, have been depicted in Figure 3 for WY98. Flows peaked during February in response to severe winter storms and flooding. Statewide, twice the normal precipitation occurred during

Figure 2. Comparison of Rainfall at and Discharge Flows from Friant Dam into the San Joaquin River: Water Year 1998

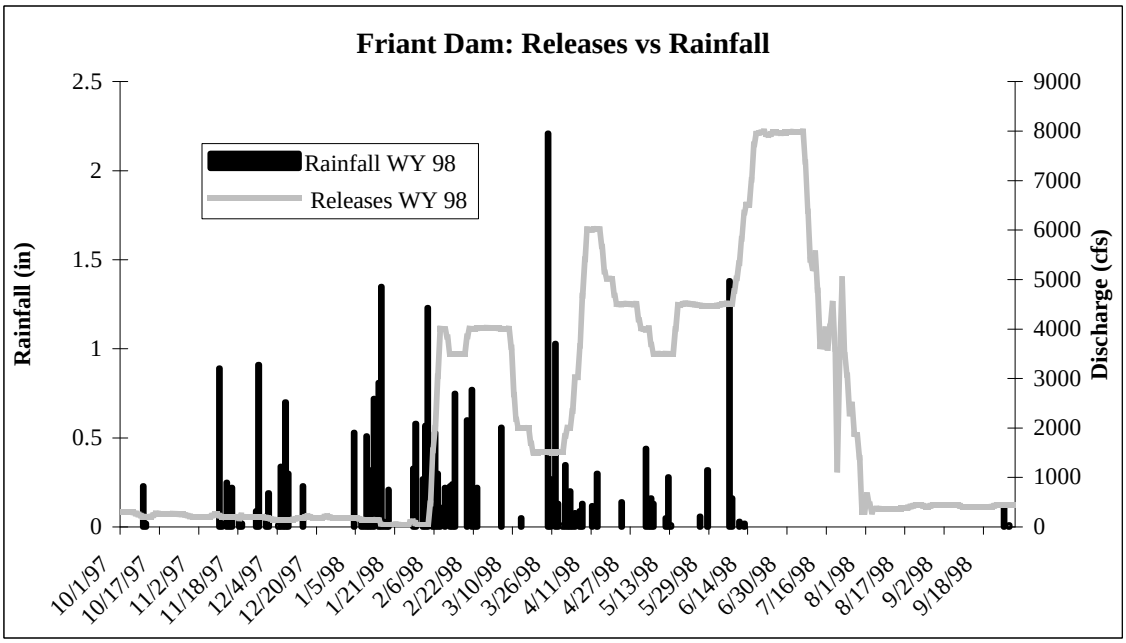
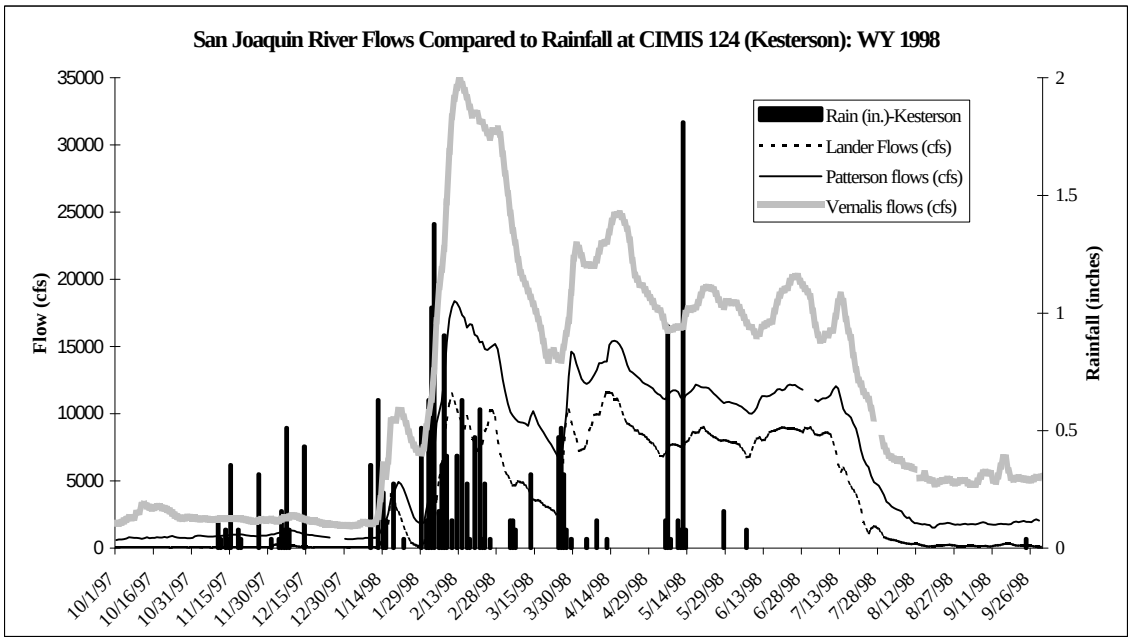


Figure 3. Comparison of Rainfall at CIMIS Station 124 (Kesterson NWR) and Flows in the San Joaquin River at Lander Avenue, Patterson and Vernalis: Water Year 1998



January and over three times the normal occurred in February (DWR, 1999). At some locations, rainfall totals reached record highs during the month of February--for example, 7.7 inches at Kesterson National Wildlife Refuge gauge--resulting in localized flooding in the Drainage Problem Area. The localized flooding in turn resulted in the diversion of commingled agricultural subsurface and storm drainage flows from the Drainage Project Area into both Mud Slough (north) and Salt Slough between 3 and 28 February, with ultimate discharge into the San Joaquin River. The elevated flows from the Grassland Watershed continued into June 1998 (Chilcott et al., 2000a). Flood conditions along the Lower San Joaquin River during these time periods disrupted sampling and resulted in limited water quality data at some sites.

RESULTS

Water quality analytical results for minerals and trace elements, as well as EC, pH, and temperature at time of sampling, are listed by site in Appendices A and B. Appendix A includes all grab sample data collected during WY98 while Appendix B contains all information collected using automated Sigma samplers. The number of sampling events and the ranges, mean, geometric mean and median concentrations for each measured constituent at each site are shown in these appendices. The results have been grouped into three sections for discussion. The first section covers electrical conductivity, boron and selenium, the second section reviews results for other constituents of concern, and the final section review preliminary results for the eastside tributaries.

Electrical Conductivity, Boron and Selenium

Electrical conductivity, boron and selenium results have been grouped by grab samples or daily composite samples. Grab sample results are presented by site in the order of the site's location on the San Joaquin River. The first site, the San Joaquin River at Lander Avenue, is the furthest upstream and considered the background site for this program. The subsequent sites discussed progress downstream from the Lander Avenue site. Table 4 summarizes annual minimum, median and maximum EC, boron and selenium concentrations in the river during WY98 and compares those values to the average range in concentration during the 11 water years of record prior to Grassland Bypass Project conditions (water years 1986 through 1996). Those 11 years of record contained seven critically dry years and four wet years as determined using the San Joaquin River Index (SWRCB, 1995). Since WY98 was classified as a wet water year, the 11-year data record summary information has also been separated into critically dry years and wet years. The data for WY97 (also a wet water year) has been listed separately to reflect the opening of the bypass channel which altered the water characteristics in the river downstream of Salt Slough. Results from the autosamplers which collected composite samples from the Crows Landing and Las Palmas (Patterson) sites have also been presented.

Grab Samples

During WY98, the background site on the San Joaquin River at Lander Avenue was sampled weekly for EC and quarterly for boron and selenium. Mean annual EC, boron and selenium values were 394 µmhos/cm, <0.05 mg/L and 0.4 µg/L, respectively. Both the mean and

Table 4. Annual Minimum, Mean, and Maximum Electrical Conductivity, Boron, and Selenium at Monitoring Sites On the San Joaquin River: Water Years 86-96, 1997 and 1998.

Site	Count	EC (umhos/cm)			Boron (mg/L)			Selenium (ug/L)		
		Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
SJR @ Lander Avenue										
WYs 86-96	400	46	1430	4060	<0.05	0.34	1.1	<0.4	0.5	5.0
WYs 86-96(critical)	304	100	1730	3990	<0.05	0.36	0.98	0.4	0.5	1.8
WYs 86-96 (wet)	96	46	865	4060	<0.05	0.27	1.1	<0.4	0.5	5.0
WY 97	6	88	767	1600	<0.05	0.06	0.2	<0.4	<0.4	<0.4
WY 98	***11***	***46***	***394***	***1530***	***<0.05***	***<0.05***	***0.11***	***<0.4***	***0.4***	***1.1***
SJR @ Freemont Ford										
WYs 86-96	474	64	2060	4290	<0.05	1.7	4.9	<0.4	11.6	35.2
WYs 86-96(critical)	313	600	2300	4290	0.28	1.9	4.9	0.8	13.2	35.2
WYs 86-96 (wet)	161	64	1600	4050	<0.05	1.3	3.5	<0.4	8.5	29.0
WY 97	47	85	1090	2110	0.08	0.47	0.96	<0.4	0.8	1.8
WY 98	***52***	***48***	***708***	***2830***	***<0.05***	***0.33***	***1.2***	***<0.4***	***0.6***	***1.3***
SJR @ Hills Ferry										
WYs 86-96	472	178	2100	4360	0.09	1.7	5.0	<0.4	9.6	28.4
WYs 86-96(critical)	308	750	2350	4360	0.34	1.9	5.0	1.0	10.9	28.4
WYs 86-96 (wet)	164	178	1630	3650	0.09	1.3	3.0	<0.4	7.1	23.0
WY 97	46	76	1540	2700	<0.05	1.3	2.5	<0.4	6.8	18.0
WY 98	***52***	***208***	***1020***	***2710***	***0.18***	***0.84***	***1.9***	***0.9***	***3.1***	***7.8***
SJR @ Crows Landing										
WYs 86-96	482	135	1330	2490	<0.05	0.94	2.1	<0.4	5.2	17.0
WYs 86-96(critical)	315	209	1570	2490	0.11	1.1	2.1	0.5	6.2	17.0
WYs 86-96 (wet)	167	135	898	2060	<0.05	0.61	2.1	<0.4	3.3	12.0
WY 97	48	128	880	1460	0.06	0.62	1.2	<0.4	2.9	8.2
WY 98	***52***	***133***	***648***	***1700***	***0.08***	***0.45***	***1.1***	***0.5***	***1.6***	***3.4***
SJR @ Patterson										
WYs 86-96	354	146	1270	2450	0.06	0.80	3.0	<0.4	4.0	14.0
WYs 86-96(critical)	191	249	1530	2450	0.11	0.98	3.0	0.5	4.9	14.0
WYs 86-96 (wet)	163	146	958	2120	0.06	0.60	1.8	<0.4	3.0	11.0
WY 97	47	218	893	1510	0.11	0.58	1.0	0.5	2.8	7.0
WY 98	***52***	***137***	***683***	***1700***	***0.08***	***0.44***	***1.0***	***0.5***	***1.5***	***3.5***
SJR @ Maze Blvd.										
WYs 86-96	385	125	991	1750	<0.05	0.56	1.3	<0.4	2.7	9.8
WYs 86-96(critical)	234	211	1190	1750	0.08	0.68	1.3	<0.4	3.3	9.8
WYs 86-96 (wet)	151	125	680	1620	<0.05	0.38	0.92	<0.4	1.8	4.9
WY 97	47	172	625	1110	0.09	0.35	0.68	<0.4	1.5	4.7
WY 98	***50***	***122***	***457***	***1200***	***0.07***	***0.27***	***0.67***	***0.4***	***0.9***	***2.1***
SJR @ Vernalis (Airport Road)										
WYs 86-96	476	123	810	1680	<0.05	0.44	1.2	<0.4	2.2	9.6
WYs 86-96(critical)	313	217	931	1680	<0.05	0.51	1.2	0.4	2.5	9.6
WYs 86-96 (wet)	162	123	575	1420	<0.05	0.31	0.83	<0.4	1.5	6.1
WY 97	45	156	491	816	0.07	0.25	0.43	<0.4	1.0	2.9
WY 98	***53***	***141***	***414***	***983***	***0.07***	***0.22***	***0.57***	***<0.4***	***0.7***	***1.5***
Autosampler Data										
SJR @ Crows Landing										
WY 97	327	121	909	1740	0.05	0.68	1.6	<0.4	3.2	10.0
WY 98	***342***	***126***	***649***	***1790***	***0.07***	***0.45***	***1.1***	***0.4***	***1.5***	***4.1***
SJR @ Patterson										
4/10/98-8/6/98 ***WY 98***	***117***	***137***	***251***	***660***	***0.08***	***0.15***	***0.46***	***<0.4***	***0.9***	***2.6***

Count = the minimum number of analyses out of the three constituents

Water year type is based on the San Joaquin 60-20-20 River Index as follows:

Critical Water Year: Runoff < 2.1 million ac-ft (WYS 87-92 and 94)

Wet Water Year: Runoff > 3.81 million ac-ft (WYs 86, 93, 95, 96, and 97)

maximum boron and EC concentrations in the San Joaquin River at Lander Avenue during WY98, were lower than the means or maximums during the previous 12 years for either the dry or wet water years. Selenium concentrations recorded during WY98 more closely resembled those of the previous years.

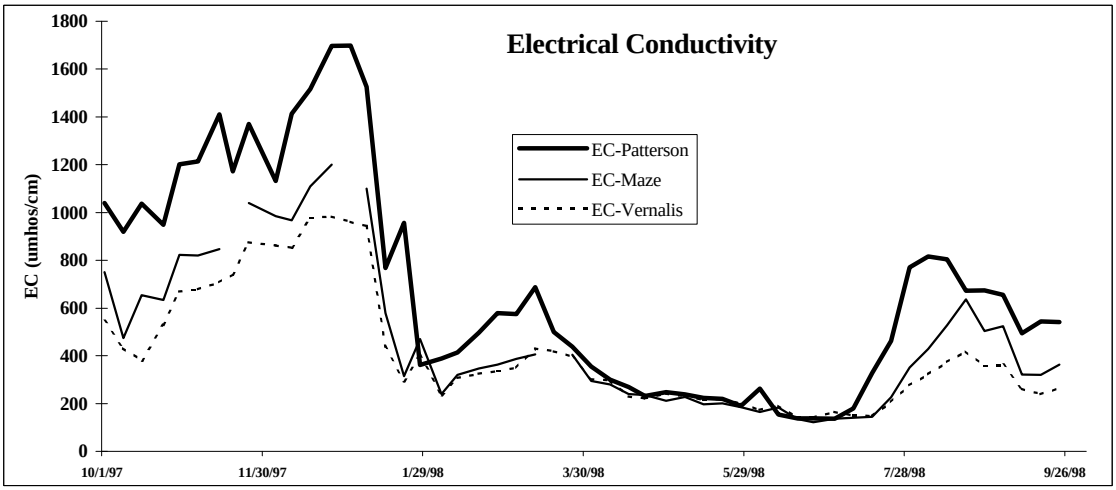
Constituent concentrations at the Fremont Ford site reflect operation of the Grassland Bypass Project which resulted in the diversion of subsurface agricultural drainage water out of Salt Slough and into Mud Slough (north), in WY97. Salt Slough discharges into the San Joaquin River upstream of the Fremont Ford site and Mud Slough (north) discharges into the San Joaquin River downstream of the Fremont Ford site. After the Grassland Bypass Project went into operation, concentrations of all constituents of concern decreased at the Fremont Ford site. Mean EC, boron, and selenium concentrations dropped from 1600 µmhos/cm, 1.3 mg/L, and 8.5 µg/L, respectively, for wet water years between 1986 and 1996, to 1090 µmhos/cm, 0.47 mg/L, and 0.8 µg/L, respectively, during WY97, and 708 µmhos/cm, 0.33 mg/L, and 0.6 µg/L, respectively, during WY98. The overall decreases can be directly attributed to the redirection of the majority of subsurface agricultural drainage flows to Mud Slough (north) from Salt Slough, even though, between 3 and 28 February 1998, commingled storm and drainage flows were released into both sloughs.

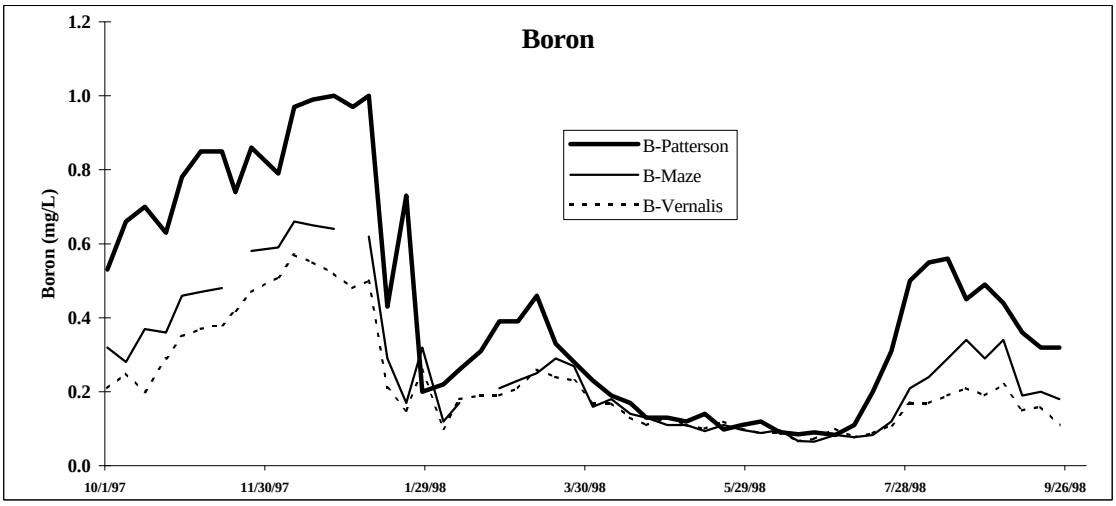
The San Joaquin River at Hills Ferry Road is downstream of the inflows from both Mud Slough (north) and Salt Slough and upstream of the eastside tributaries. Recent aerial surveillance and ground truthing indicate that the site is downstream of some portion of the Merced River inflow during some flow regimes. EC concentrations at the Hills Ferry site varied widely during WY98, ranging from 208 µmhos/cm (following the flood events of February 1998) to 2710 µmhos/cm with a mean of 1020 µmhos/cm. Mean concentrations for boron and selenium at the Hills Ferry Road site were the highest of all the sites sampled in WY98 at 0.84 mg/L and 3.1 µg/L, respectively. Maximum boron and selenium concentrations reached 1.9 mg/L and 7.8 µg/L, respectively. Mean and maximum concentrations of these constituents were lower in WY98 than during previous wet water years and substantially lower than during critically dry years.

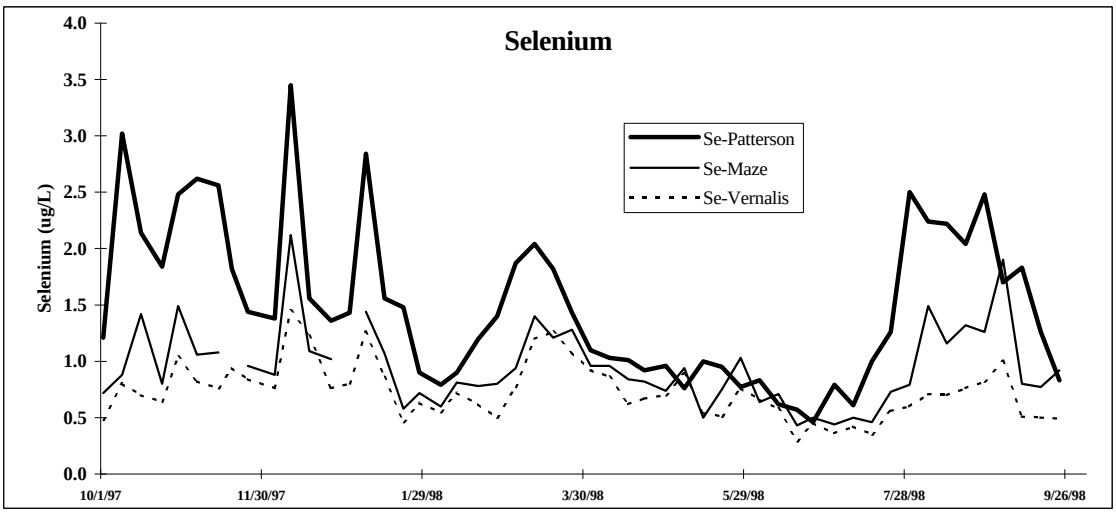
Freshwater inflow from the Merced River, diluted constituent concentrations in the San Joaquin River at the downstream Crows Landing sampling location. Grab samples for EC, boron and selenium recorded maximum concentrations of 1700 µmhos/cm, 1.1 mg/L, and 3.4 µg/L, respectively, and mean values of 648 µmhos/cm, 0.45 mg/L, and 1.6 µg/L, respectively.

Concentrations continued to decrease downstream in the San Joaquin River with the inflow from two additional east side tributaries: the Tuolumne and Stanislaus Rivers. Salt, boron and selenium concentrations are very low in these tributaries and improve the water quality in the San Joaquin River accordingly. The Las Palmas site near Patterson, is just upstream of these tributary inflows and concentrations at this site are similar to those measured at the Crows Landing Bridge site. Monitoring sites downstream of the Las Palmas site showed decreasing constituent concentrations. At the farthest downstream sampling location, the San Joaquin River at Vernalis, ECs ranged from 141 to 983 µmhos/cm, while mean boron and selenium concentrations were 0.22 mg/L and 0.7 µg/L, respectively. Figure 4 shows the constituent concentrations in the San Joaquin River at Las Palmas, Maze Blvd., and Vernalis.

Figure 4. Comparison of Weekly Measurements of Electrical Conductivity, Boron and Selenium Concentrations in the San Joaquin River at Patterson (Las Palmas), Maze Blvd. and Vernalis: WY 98







Daily Composite Samples

During WY98, daily composite water samples for EC, boron and selenium were collected year round from the San Joaquin River at the Crows Landing site and between 10 April and 6 August 1998 at the Patterson site using automated Sigma samplers. Some data gaps occurred within the Crows Landing sample set, primarily due to programming errors. These gaps occurred as follows:

13 - 19 November 1997
9 - 19 March 1998
14 and 15 June 1998
30 and 31 July 1998

All available data has been presented in Appendix B. Figure 5 presents a comparison of boron and selenium water quality information from the composite samples with grab samples collected during the same time period.

Values recorded in the San Joaquin River at Crows Landing demonstrate the influence of dilution flows on the water quality at that site. During the high runoff (February through July 1998), selenium concentrations typically remained at or below 1 µg/L, with concentrations only reaching 2 µg/L during a short time period in late March and after August when flows decreased. Corresponding patterns of high and low concentrations were also evident for EC and boron. The highest concentrations of EC, boron and selenium were observed prior to the February 1998 storms and after August 1998, when flows in the river were at their lowest. Figure 6 compares the daily composite EC values with the daily discharge at the site.

Sigma data collected from the San Joaquin River at the Patterson site has been presented in Appendix B. The site was initiated after high water levels rendered the Crows Landing site inaccessible except by boat. A comparison of the composite data from the two sites was completed to determine if the more accessible Patterson site would be an appropriate alternate site during high river flows. Figure 7 shows a graphical comparison of the EC, boron, and selenium data collected at the two sites between 10 April 1998 and 6 August 1998, and the differences in the paired samples over time.

Statistical analysis of the data was conducted using a paired t-test on the individual differences between results for each sample date at the 95% confidence level ($\alpha = 0.05$). The paired samples collected at the two sites for boron and selenium were determined not to be significantly different at this level of confidence. However, a significant difference in the measured EC between the two sites was noted, with EC values recorded at the Patterson site slightly elevated over the EC values recorded at the Crows Landing site.

Other Elements of Concern

During WY98, limited additional water quality analyses were conducted quarterly for copper, chromium, lead, nickel and zinc, and molybdenum at four sites along the San Joaquin River: Lander Avenue, Hills Ferry, Crows Landing, and Vernalis. Results which satisfied the quality

Figure 5. Comparison of Electrical Conductivity, Boron and Selenium from Weekly Grabs vs. Autosampler Collections in the San Joaquin River at Crows Landing: Water Year 1998

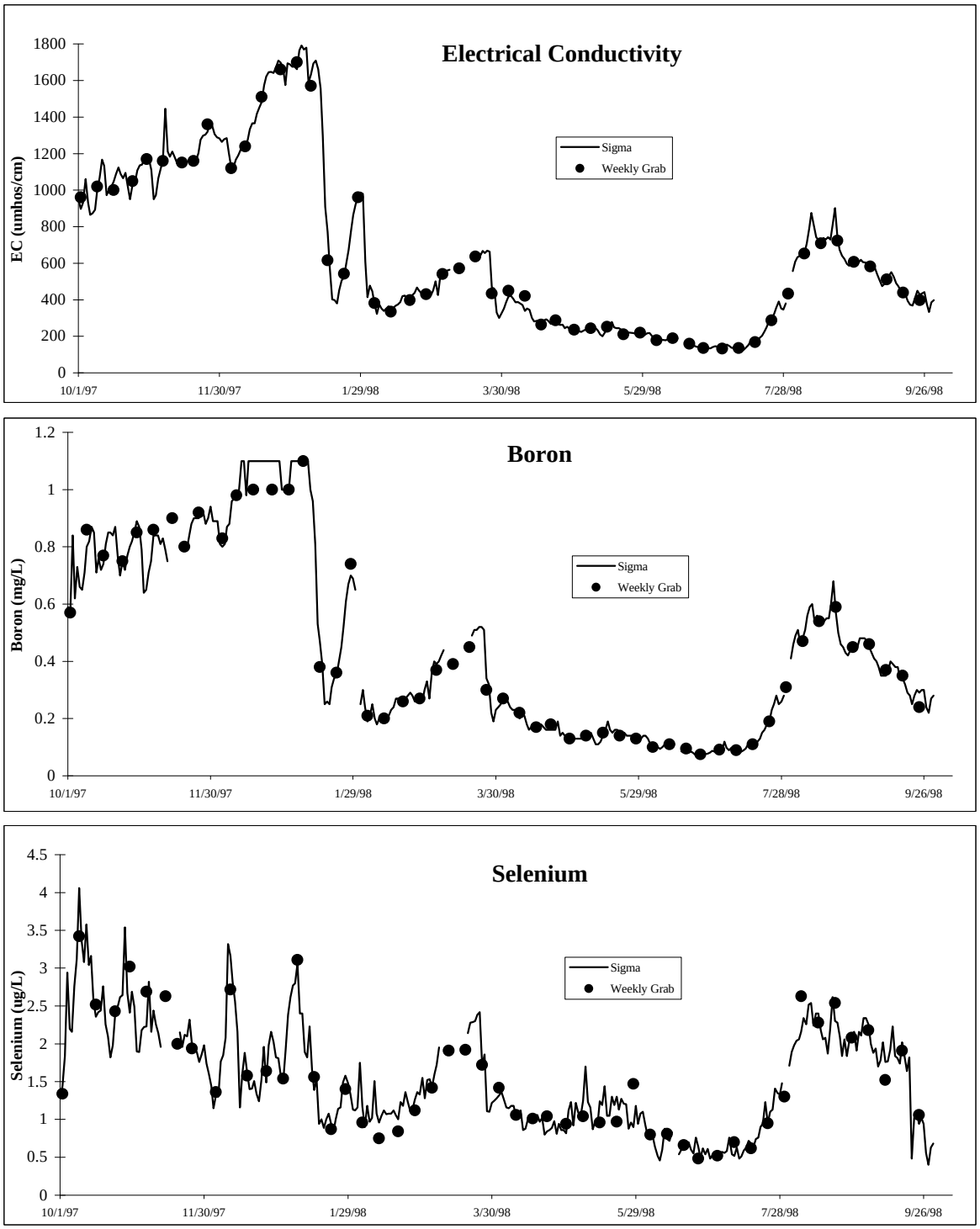
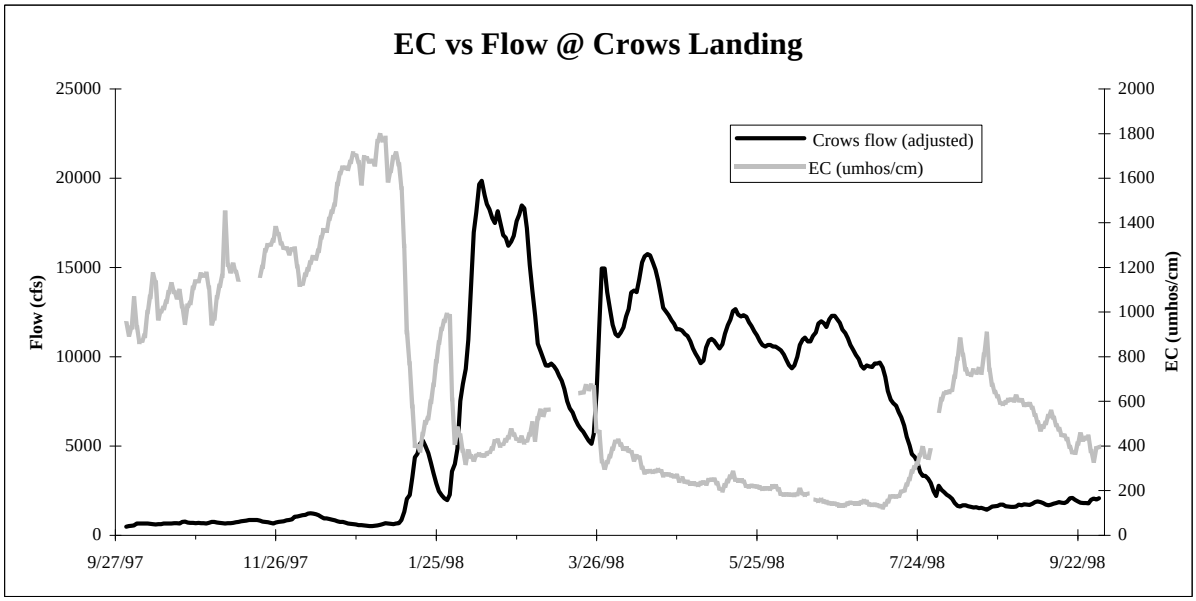


Figure 6. Daily Composite Electrical Conductivity vs Discharge in the San Joaquin River at Crows Landing: WY 98.



control criteria listed in Table 3, have been summarized in Table 5. None of the concentrations noted reach or exceed existing water quality objectives.

Eastside Tributaries

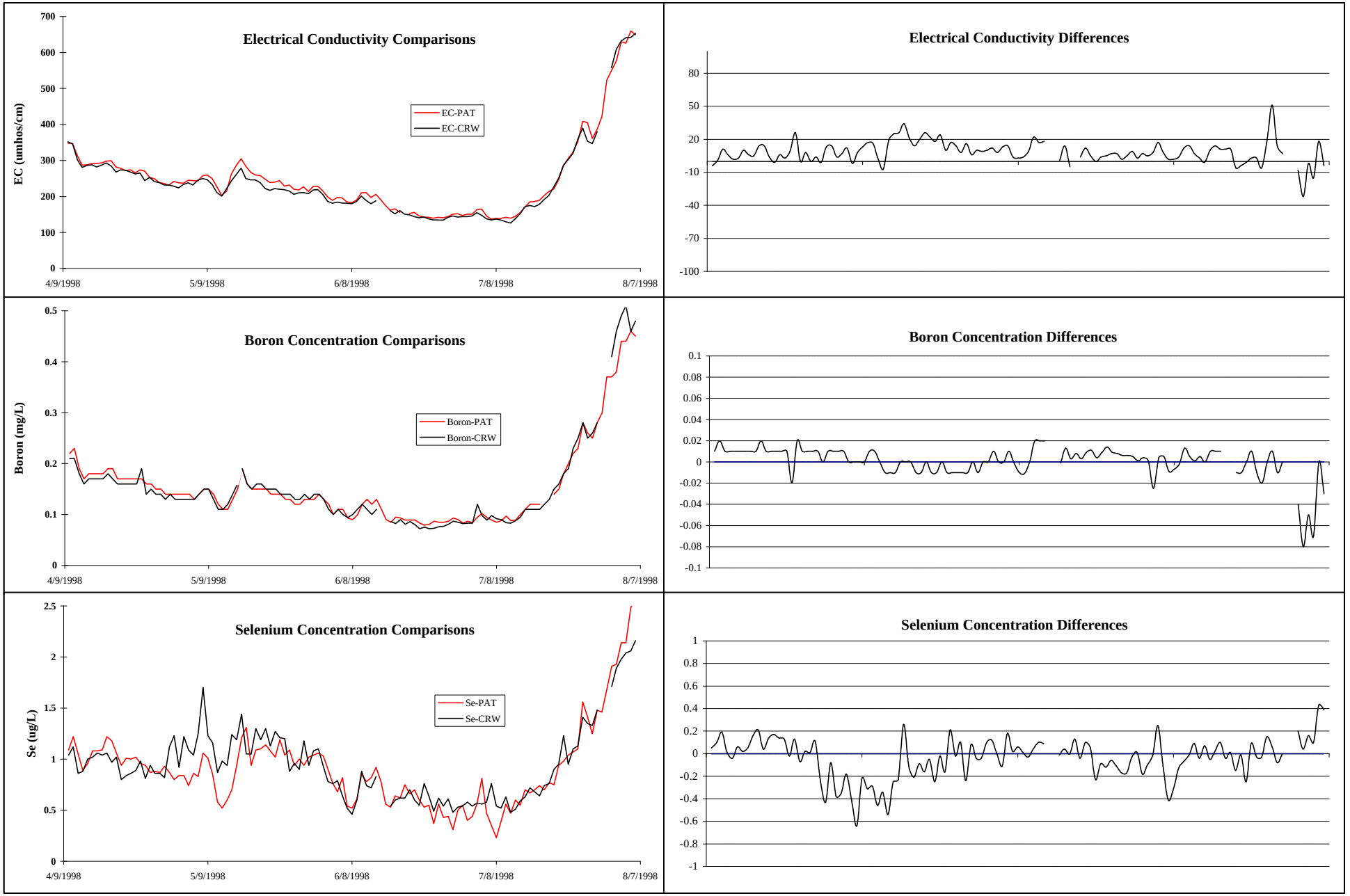
Quarterly grab sampling was initiated on the eastside tributaries, the Merced, Tuolumne, and Stanislaus Rivers, during WY98. The samples were collected during January, April and June 1998. In general, water quality from all three eastside tributaries was very good, with EC values ranging from 50 to 100 umhos/cm and boron, selenium, copper, chromium, lead, nickel and zinc all reported below their respective detection limits.

Table 5. Summary of Copper, Chromium, Lead, Nickel, Zinc and Molybdenum Results at Selected Sites in the Lower San Joaquin River: Water Year 1998.

	Total Concentrations (ug/L) in the San Joaquin River at:															
	Lander Avenue				Hills Ferry				Crows Landing				Vernalis			
Constituent	count	min	mean	max	count	min	mean	max	count	min	mean	max	count	min	mean	max
Cu	4	1.5	3.1	5.8	3	1.9	3.2	5.4	4	2.2	3.3	4.4	3	1.8	2.1	2.3
Cr	4	1	2	4	3	2.6	3.6	5.5	4	1.9	2.2	2.6	3	2.5	3.1	4.4
Pb	4	<5	<5	<5	3	<5	<5	<5	4	<5	<5	<5	3	<5	<5	<5
Ni	4	<5	3.3	5.6	3	<5	4.5	8.6	4	<5	<5	<5	3	<5	<5	<5
Zn	1	5.8	5.8	5.8	0	na	na	na	1	6.5	6.5	6.5	0	na	na	na
Mo	4	1	3	7	7	2	6	11	7	2	4	8	6	1	3	5

na = not available

Figure 7. Comparison of EC, Boron and Selenium Values at Automated Samplers at Patterson and Crows Landing: April 10, 1998 - August 6, 1998.



DISCUSSION

Comparison to Pre-Project Conditions and Water Year 1997

When the Grassland Bypass became operational at the end of September 1997, it effectively consolidated agricultural subsurface drainage from the Drainage Project Area into a single channel for discharge into the final nine miles of Mud Slough (north). This consolidation removed the subsurface drainage from approximately 90 miles of wetland water supply channels and from Salt Slough.

Table 4 lists minimum, mean, and maximum electrical conductivity, boron and selenium concentrations for wet water years 1997 and 1998 as well as a summary for all the wet water years that occurred between water years 1986 and 1996 (pre-project).

In general, concentrations of all constituents measured during wet WY98, were lower than concentrations measured during previous wet water years. The reduction in constituent concentrations can be attributed to two major factors: continued high rainfall and high dilution flows between January and June 1998; and impacts from the Grassland Bypass Project.

A good example of the pattern displayed along the entire lower reach of the San Joaquin River is the Lander Avenue site. The Lander Avenue site serves as the background site for this monitoring program since it is upstream of most major discharges into the lower stem of the San Joaquin River and since flows upstream of the site are usually limited to groundwater accretions. The mean EC, boron and selenium concentrations at Lander Avenue during wet WY98 as compared to the wet water years between 1986 and 1996 were 394 vs. 865 umhos/cm, <0.05 vs. 0.27 mg/L, and 0.4 vs. 0.5 µg/L, respectively. Maximum EC, boron and selenium concentrations at the site showed were also lower during WY98 than previous wet water years at 1530 vs. 4060 µmhos/cm, 0.11 vs. 1.1 mg/L, and 1.1 vs 5.0 µg/L, respectively. The lower concentrations evident during WY98 are most likely due to the extended period of high inflows to the site attributed to releases from Friant Dam (Figure 2).

The pattern continued downstream, although the opening of the Grassland Bypass also impacted the hydrology of the lower San Joaquin River beginning in WY97. The immediate impact of the bypass was to divert subsurface agricultural drainage from Salt Slough into Mud Slough (north) thereby removing the subsurface drainage from the San Joaquin River at Fremont Ford. That impact is clear given the lower concentrations of all constituents at the Fremont Ford site during wet WY97 as compared to previous wet water years (Table 4). The overall decrease in concentration continued during WY98. Mean values for WY98 are substantially lower than WY97, although maximum EC and boron values are slightly higher. The lower mean concentration is likely due to the extended period of high dilution flows. The higher maximum concentrations occurred just prior to the winter storm events in February 1998, during a period of low flow in the river channel.

The pattern continued downstream, with mean and maximum WY98 concentrations consistently lower than pre-bypass wet water years, and mean concentrations lower than post-bypass WY97.

Maximum EC concentrations continued to be slightly higher during WY98 than during WY97, while maximum selenium concentrations were considerably lower.

Comparison to Applicable Water Quality Objectives

In October 1988, the Regional Board adopted water quality objectives for boron, molybdenum and selenium for the lower San Joaquin River between Sack Dam and Vernalis. Two sets of objectives were developed. One set of objectives was established for the river reach with minimal freshwater flow, between Sack Dam and the inflow from the Merced River. The second set was established for the reach of river from the inflow of the Merced River to Vernalis, which has highly managed freshwater inflows. The objectives were also based on water year type, as classified by the San Joaquin River Index (SWRCB, 1987 and SWRCB, 1995), and season. Slightly relaxed objectives were implemented during critical water years reflecting the lack of good quality dilution flows from tailwater and/or flows from the eastside tributaries. In addition, more stringent boron objectives were adopted during the irrigation season, 15 March through 15 September, when downstream crops would be susceptible to boron toxicity from irrigation water. As specified in the amendment, compliance monitoring for selenium and boron water quality objectives is conducted on the San Joaquin River at the Crows Landing Road Bridge site. The Crows Landing Road Bridge site is downstream of the Merced River inflow and also receives water from agricultural return flows and groundwater seepage.

In May 1996, the Regional Board adopted revised selenium water quality objectives for the lower San Joaquin River as well as a compliance time schedule which includes performance goals. The water quality objectives for boron, selenium and molybdenum, which applied to the two segments of the lower San Joaquin River during WY98 (a wet water year), have been listed in Table 6. The compliance time schedule and performance goals which apply to the selenium objective, are listed in Table 7.

Table 6. Boron, Selenium and Molybdenum Water Quality Objectives for the Lower San Joaquin River

	Boron (mg/L)		Selenium (µg/L)		Molybdenum (µg/L)	
Water Body	Continuous	Maximum	Continuous	Maximum	Continuous	Maximum
San Joaquin River between Sack Dam and the Merced River Inflow						
WY 1998	2.0 (monthly mean)†	5.8	5 (4-day average)*	20	19 (monthly mean)	50
San Joaquin River from the Merced River Inflow to Vernalis						
WY 1998	0.8 (monthly mean)† 1.0 (monthly mean)††	2.0† 2.6††	5 (4-day average)**	12	10 (monthly mean)	15

† = This water quality objective applies from 15 March through 15 September
†† = Thi water quality objective applies from 16 September through 14 March
* = Compliance time schedule adopted and in effect until October 2010
** = Compliance time schedule adopted and in effect until October 2005

Table 7. Summary of Selenium Water Quality Objectives and Compliance Time Schedule

[Selenium Water Quality Objectives (in bold) and Performance Goals (in italics)]

Water Body/ Water Year Type [1]	1 October 1996	1 October 2002	1 October 2005	1 October 2010
San Joaquin River below the Merced River; Above Normal and Wet Water Year types		*5 µg/L monthly mean*	**5 µg/L 4-day average**	
San Joaquin River below the Merced River; Critical, Dry, and Below Normal Water Year types		*8 µg/L monthly mean*	*5 µg/L monthly mean*	**5 µg/L 4-day average**
San Joaquin River from Sack Dam to the Merced River.				**5 µg/L 4-day average**

[1] The water year classification will be established using the best available estimate of the 60-20-20 San Joaquin Valley water year hydrologic classification (as defined in Footnote 17 for Table 3 in the State Water Resources Control Board's *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, May 1995) at the 75% exceedance level using data from the Department of Water Resources Bullentin 120 series. The previous water year's classification will apply until an estimate is made of the current water year.

Boron

Separate boron water quality objectives apply to the lower San Joaquin River upstream and downstream of the Merced River inflow. Downstream of the Merced River, the objectives are further divided seasonally: 0.8 mg/L during the irrigation season (15 March through 15 September) and 1.0 mg/L for the remainder of the year. Table 8 lists the mean monthly boron concentrations at all sites monitored in the San Joaquin River for WY98 and indicates whether the applicable monthly mean water quality objective was exceeded.

During WY98, the applicable monthly mean boron objectives were not exceeded in the Lower San Joaquin River based on weekly grab samples. Review of the daily composited data from the Crows Landing site also indicated no exceedances. The instantaneous maximum boron water quality objectives (2.0 mg/L to 5.8 mg/L, depending on river location and time of year) were not exceeded during WY98. The highest boron concentration recorded was 1.9 mg/L at Hills Ferry during early January 1998.

Selenium

The selenium water quality objective was revised on 10 January 1997. The continuous selenium objective became 5 µg/L based on a 4-day average, and is subject to a compliance time schedule (Table 7). The compliance timetable includes performance goals, expressed as monthly means, that become effective 1 October 2002. The maximum objective still varies according to location (Table 6).

Table 8. Monthly Mean Boron Concentrations and Water Quality Objective (WQO) Exceedances in the San Joaquin River: Water Year 1998.

Water Year/Site	WQO mg/L	Monthly Mean Concentration (mg/L)											
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Lander Avenue*	2†	<0.05	na	na	0.11	0.06	<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05
Freemont Ford	2†	0.55	0.84	0.98	0.71	0.06	0.17	0.05	<0.05	<0.05	0.06	0.25	0.23
Hills Ferry	2†	1.3	1.4	1.4	1.2	0.7	0.69	0.49	0.35	0.21	0.34	1.0	0.97
Crows Landing	0.8/1.0††	0.76	0.87	0.95	0.72	0.24	0.38	0.19	0.14	0.10	0.16	0.51	0.36
Las Palmas	0.8/1.0††	0.66	0.85	0.94	0.78	0.25	0.39	0.20	0.12	0.10	0.16	0.52	0.40
Maze Blvd.	0.8/1.0††	0.36	0.51	0.64	0.35	0.29	0.26	0.14	0.10	0.08	0.11	0.29	0.23
Vernalis	0.8/1.0††	0.26	0.41	0.54	0.32	0.17	0.24	0.14	0.11	0.08	0.11	0.19	0.16
Crows Ldg Sigma	0.8/1.0††	0.77	0.83	1.0	0.71	0.24	0.38	0.19	0.14	0.09	0.14	0.51	0.34

† = water quality objective applies 15 March through 15 September

†† = 0.8 mg/L objective applies 15 March through 15 September; 1.0 mg/L objective applies 16 September through 14 March

* = analyzed quarterly or monthly

Bold Italic = water quality objective exceedance

Table 9. Monthly Mean Selenium Concentrations and Potential Water Quality Objective (WQO) Exceedances in the San Joaquin River: Water Year 1998.

Water Year/Site	WQO* µg/L	Monthly Mean Concentration (µg/L)											
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Lander Avenue**	5	<0.4	na	na	0.5	1.1	0.6	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Freemont Ford	5	0.8	0.6	1.2	0.8	0.4	0.6	<0.4	<0.4	<0.4	<0.4	0.6	0.5
Hills Ferry	5	***5.1***	3.8	2.7	2.8	2.4	3.1	2.7	2.3	1.4	1.6	4.9	4.8
Crows Landing	5	2.5	2.3	1.8	1.7	0.9	1.7	1.1	1.1	0.7	0.8	2.4	1.7
Las Palmas	5	2.1	2.2	1.9	1.8	0.9	1.8	1.1	0.9	0.7	0.8	2.3	1.6
Maze Blvd.	5	1.1	1.0	1.3	1.0	0.7	1.2	0.9	0.8	0.6	0.6	1.3	0.9
Vernalis	5	0.7	0.8	1.1	0.8	0.6	1.1	0.8	0.7	0.5	0.5	0.7	0.5
Crows Ldg Sigma	5	2.6	2.1	1.8	1.6	1.2	1.7	1.0	1.1	0.7	0.8	2.1	1.5

* = Water quality objective applies as a 4-day average subject to a compliance time schedule

** = analyzed quarterly or monthly

Bold Italic = water quality objective exceedance

Table 9 presents the monthly mean selenium concentrations at selected locations in the San Joaquin River, based on weekly grab samples, and indicates whether the monthly mean concentrations exceeded 5 ug/L. During WY98, the only monthly mean concentration exceeding 5 ug/L was recorded in the river at Hills Ferry, during October 1997. Monthly mean selenium concentrations at the remaining sites were all below 5 µg/L.

The maximum selenium water quality objectives which applied, 12 µg/L or 20 µg/L, depending on location (Table 6), were not exceeded at any time during WY98. The highest selenium concentration recorded in the river was 7.8 µg/L at Hills Ferry on 9 October 1997.

The concentrations listed in Table 9 are monthly mean concentrations for comparison; however, the selenium water quality objective is a 4-day average. The 5 ug/L 4-day average objective will not apply at Hills Ferry until October 2010, based on the current compliance time schedule.

Composite data collected from the Sigma automated samplers at the Crows Landing site was used to calculate actual 4-day average concentrations for WY98. None of the calculated 4-day averages exceeded 5 ug/L selenium, with the highest value calculated at 3.5 µg/L for the period of 9 through 12 October 1997. The calculated concentrations for WY98 are much lower than those calculated for WY97, likely reflecting the higher dilution flows available during the WY98 irrigation season, March through August (Figure 8). Figure 9 shows flow in the San Joaquin River at Crows Landing for WY97 and WY98.

Molybdenum

The molybdenum water quality objectives adopted for the lower San Joaquin River primarily reflect concern over the potential accumulation in livestock forage if the water is used for irrigation. Upstream of the Merced River, the monthly mean molybdenum objective is 19 µg/L with an instantaneous maximum of 50 µg/L. Downstream of the Merced River, the monthly mean molybdenum objective drops to 12 µg/L with an instantaneous maximum of 15 µg/L. The highest molybdenum concentration detected in the San Joaquin River during the study period, was 11 µg/L at the Hills Ferry site on 30 October 1997 and again on 26 December 1997. The reported maximum concentration does not exceed any of the adopted continuous or maximum molybdenum water quality objectives listed in Table 6.

Figure 8. 4-day Running Average Selenium Concentrations in the San Joaquin River at Crows Landing: Water Year 1997 and Water Year 1998

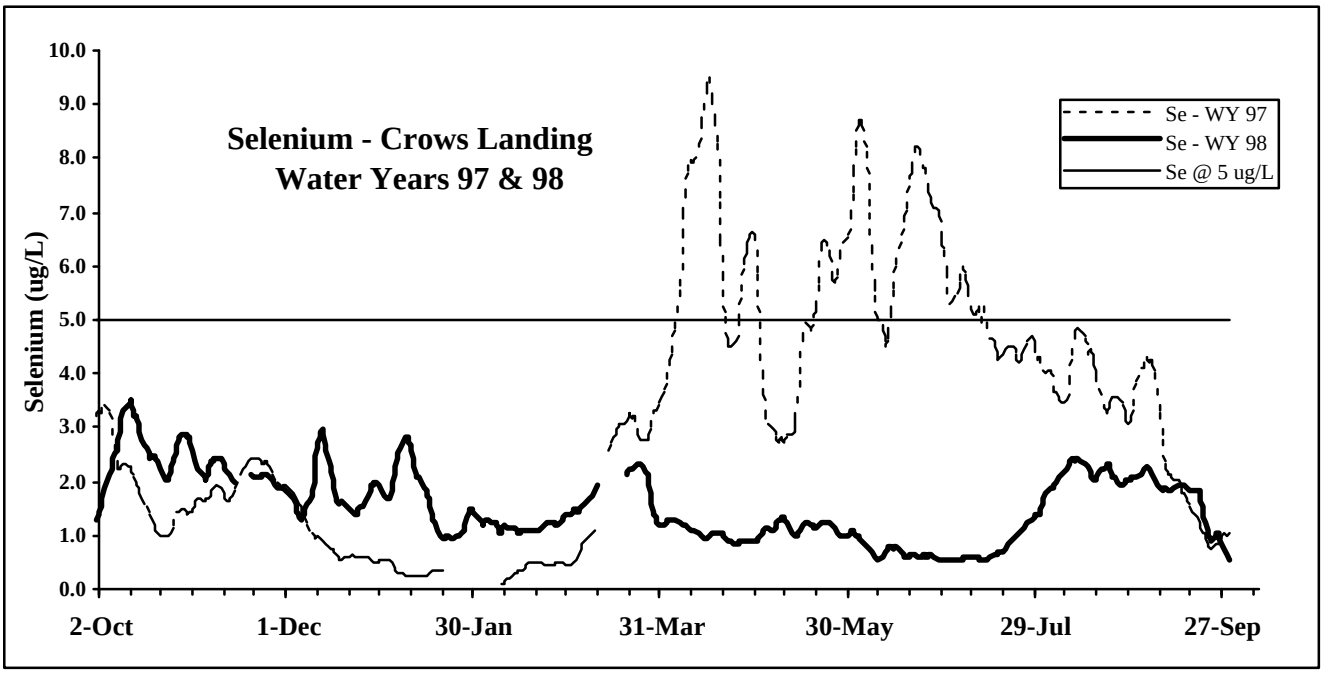
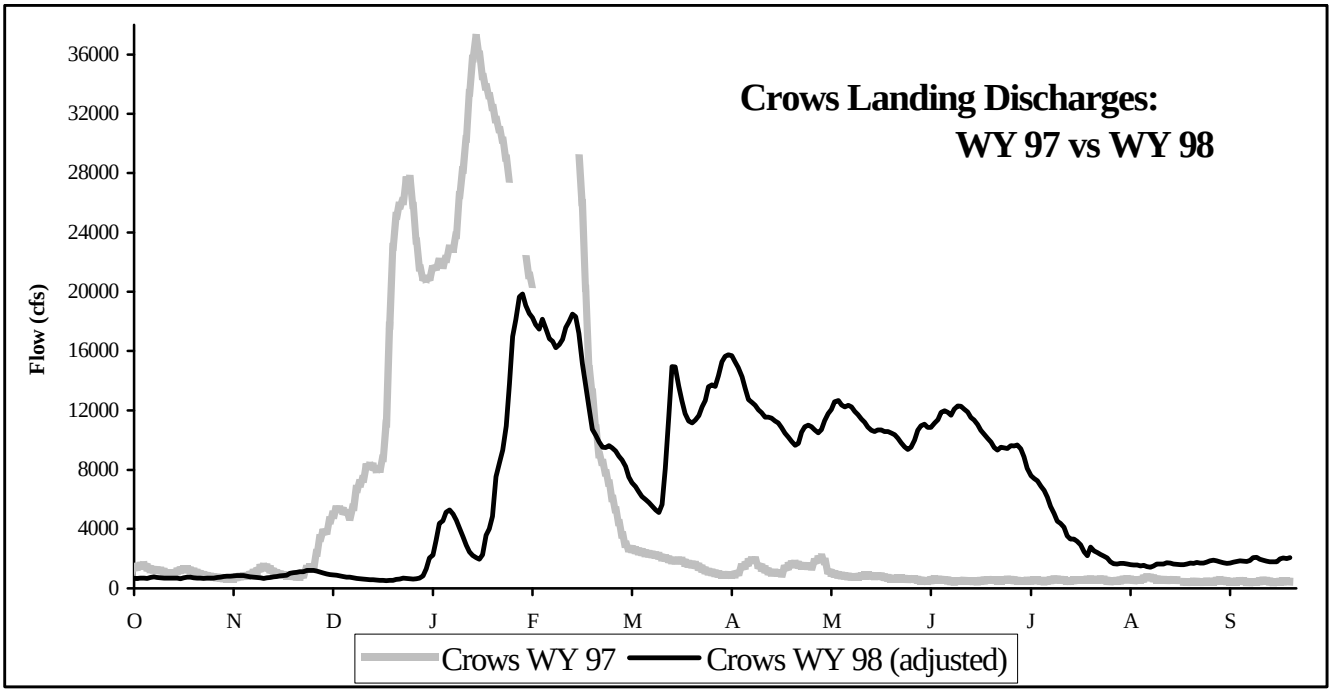


Figure 9. San Joaquin River Flows at Crows Landing: Water Years 1997 and 1998.



LOADS OF SALT, BORON, AND SELENIUM

Data Availability, Water Year 1998

Salt, boron, and selenium loads for the San Joaquin River (SJR) at Crows Landing and near Vernalis were estimated based upon the flow weighted monthly average of available water quality data for Water Year 1998. Discharge and electrical conductivity data for the sites was obtained from the US Geological Survey (Henry Miyashita, personal communication). Salt loads are based upon daily electrical conductivity measurements. Boron and selenium loads are based upon combined grab and automatic Sigma[tm] automatic sample data at Crows Landing. Only grab samples were collected and used for calculating boron and selenium loads for the SJR near Vernalis. The methodology used to calculate loads can be found in Grober et al., 1998. Raw data used to present loads have been tabulated and are available in hard copy from the Regional Board's Sacramento office. This information can also be found at the Regional Board web site. Follow the links to view or download files from:

http://www.swrcb.ca.gov/ ~rwqcb5

Tabulated flow and water quality data used to compute loads for Water Years 1986 through 1998 are presented at this website. Each year of data is comprised of four data tables; the first table contains mean daily flow data; the second, third and fourth contain electrical conductivity (EC), boron and selenium data, respectively. Additionally, EC, boron, and selenium data are presented for five Sigma[tm] automatic sampler sites for Water Years 1995 through 1998. Matrices are sparsely filled for some water quality data.

Preliminary evaluation of discharge data for the lower San Joaquin River Basin revealed possible problems with Crows Landing data. Initial review of discharge data for this site resulted in revised US Geological Survey (USGS) flow estimates for the months of March through July. Subsequent review of these revised discharges resulted in the determination to discard USGS Crows Landing flow data for the months of February through July. Combined discharge for the SJR near Newman and for Orestimba Creek at River Road was used instead of the USGS Crows Landing flow data for Crows Landing load calculations. Justification for this determination is provided in Appendix D.

Monthly Loads, Water Year 1998

Water Year 1998 monthly discharge, load, and flow weighted concentration data for the San Joaquin River at Crows Landing are based upon USGS Crows Landing discharge data for low to moderate flow months of October through January, August, and September. Discharge, load, and concentration data for the high flow months of February through July are based upon combined SJR near Newman and Orestimba Creek discharge (Table 10). The combined set of discharge data will be referred to as *adjusted* Crows Landing discharge. Monthly discharge, load, and flow weighted concentration data for the San Joaquin River near Vernalis are presented in Table 11.

Adjusted monthly discharge at Crows Landing ranged from 40 to 140 thousand acre-feet (taf) from September through January but increased dramatically in February to a high of 775 taf due to much higher than average rainfall (Figure 10). Discharge remained high through July due to continued high rainfall and snowmelt. The pattern of discharge at Vernalis was similar, with a peak discharge of 1.5 million acre-feet in February. Discharge remained over 1 million acre-feet per month through June. The seasonal pattern of monthly salt, boron, and selenium loads from these sites is similar to the pattern of discharge (Figures 11,12,13).

Table 10. Adjusted Monthly and Annual Discharge and Salt, Boron, and Selenium Loads and Flow Weighted Concentrations for SJR at Crows Landing for Water Year 1998

		Loads			Flow Weighted Concentration		
Month	Flow (taf)	Se (lbs)	B (1000 lbs)	TDS (1000 tons)	Se (ug/L)	B (mg/L)	TDS (mg/L)
Oct	40	282	84	35	2.6	0.8	643
Nov	45	259	100	49	2.1	0.8	806
Dec	53	269	140	61	1.9	1.0	838
Jan	140	482	190	81	1.3	0.5	425
Feb	775 *	2,440	510	280	1.2	0.2	266
Mar	572 *	2,510	550	244	1.6	0.4	313
Apr	742 *	2,060	380	212	1.0	0.2	210
May	684 *	2,120	260	141	1.1	0.1	151
Jun	633 *	1,140	160	98	0.7	0.1	114
Jul	414 *	805	140	57	0.7	0.1	101
Aug	108	624	150	47	2.1	0.5	321
Sep	110	454	100	42	1.5	0.3	284
WY Total	4,315	13,445	2,764	1,346	1.1	0.2	229

* Combined SJR near Newman and Orestimba Creek at River Road discharge used

Table 11 . Monthly and Annual Discharge and Salt, Boron, and Selenium Loads and Flow Weighted Concentrations for SJR near Vernalis for Water Year 1998

		Loads			Flow Weighted Concentration		
Month	Flow (taf)	Se (lbs)	B (1000 lbs)	TDS (1000 tons)	Se (ug/L)	B (mg/L)	TDS (mg/L)
Oct-97	166	353	120	64	0.8	0.3	282
Nov-97	118	269	130	62	0.8	0.4	386
Dec-97	130	379	190	95	1.1	0.5	538
Jan-98	370	674	240	117	0.7	0.2	232
Feb-98	1,561	2,570	730	348	0.6	0.2	164
Mar-98	1,190	3,370	760	334	1.0	0.2	207
Apr-98	1,305	2,670	500	275	0.8	0.1	155
May-98	1,103	2,000	320	172	0.7	0.1	114
Jun-98	1,057	1,410	230	130	0.5	0.1	90
Jul-98	811	951	220	112	0.4	0.1	102
Aug-98	335	677	170	95	0.7	0.2	210
Sep-98	343	487	150	73	0.5	0.2	156
WY Total	8,489	15,810	3,760	1,877	0.7	0.2	163

Figure 10. Monthly Discharge for the San Joaquin River at Crows Landing and near Vernalis, Water Years 1998

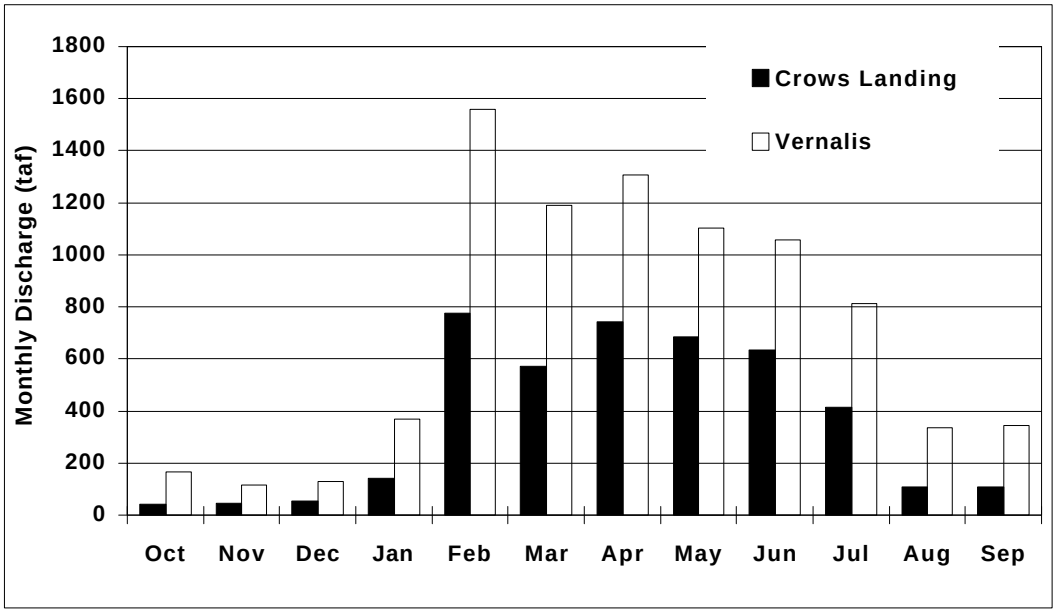


Figure 11. Monthly Salt Loads for the San Joaquin River at Crows Landing and near Vernalis, Water Years 1998

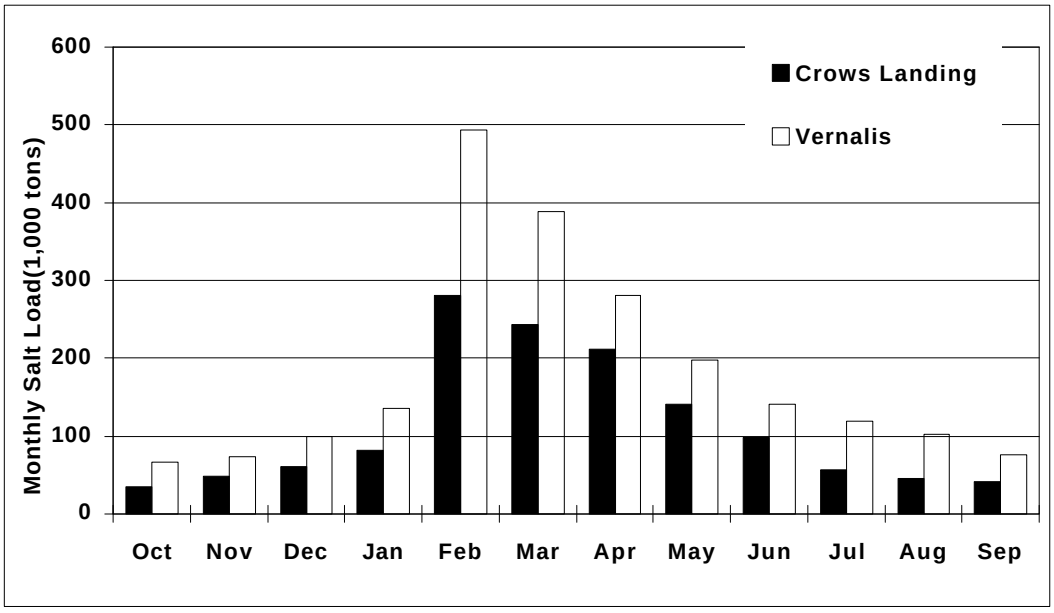


Figure 12. Monthly Boron Loads for the San Joaquin River at Crows Landing and near Vernalis, Water Years 1998

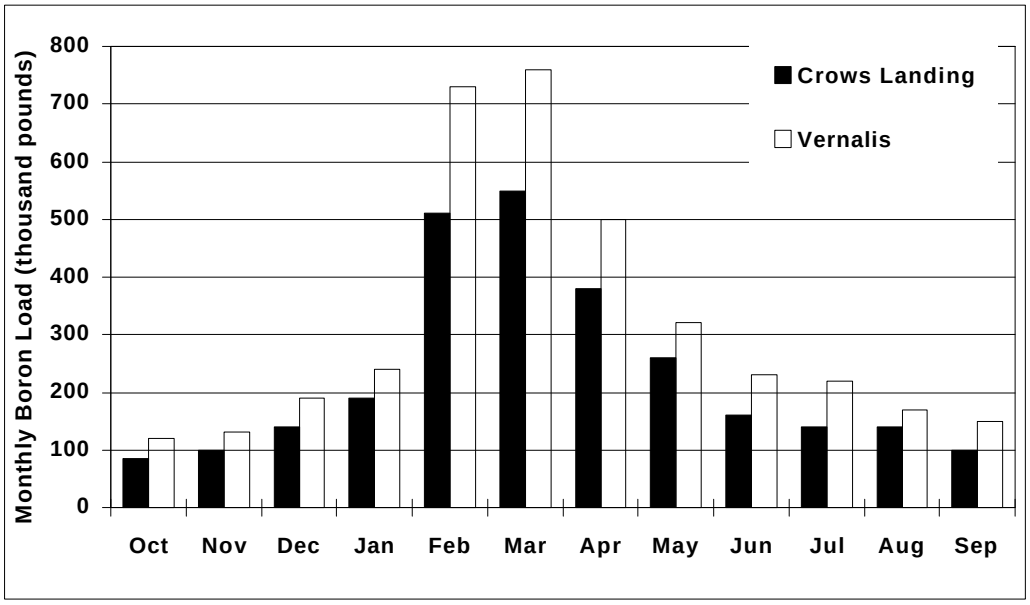
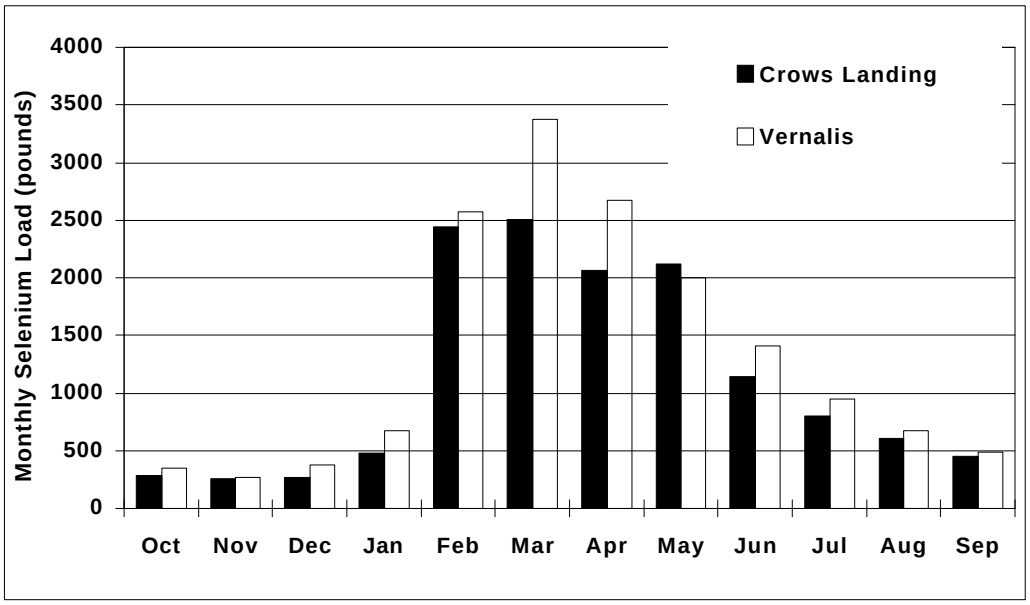


Figure 13. Monthly Selenium Loads for the San Joaquin River at Crows Landing and near Vernalis, Water Years 1998



Annual Loads, Water Year 1986 to 1998

Water Year 1998 annual discharge, load, and flow weighted concentrations for the Drainage Project Area, Grassland Watershed, and SJR at Crows Landing and near Vernalis are shown in Table 12a. Loads of all constituents are higher at Vernalis because of additional load contributed by the Tuolumne and Stanislaus Rivers on the east side, several smaller tributaries on the west side and numerous agricultural return flows from both the east and west side of the river. Unreported discharges such as these account for the "unaccounted for" loads and concentrations summarized in Tables 12b,c,d for the SJR near Vernalis. Unaccounted for sources at Crows Landing include the Merced River, the SJR upstream of the Grassland Watershed, and agricultural return flows. Unaccounted for sources for the Grassland Watershed include wetland, agricultural drainage and other drainage from within the Grassland Watershed exclusive of the Grassland Bypass Project. Other natural inflows including groundwater accretions also contribute to unaccounted for discharges and loads at all sites.

Though most selenium load recorded at the SJR sites is from the Drainage Project Area, some additional selenium load is contributed to the lower SJR at low concentrations from distributed sources throughout the basin. For example, the 13,428 pounds calculated for the SJR near Crows Landing is 3,798 pounds higher than the 9,630 pounds calculated for the Grassland Watershed for Water Year 1998 (Table 12b). The additional selenium load is associated with 3.9 million acre-feet of water contributed to the SJR from sources other than the Grassland Watershed--mostly flood flows of the SJR upstream of the Grassland Watershed. The additional selenium load can be accounted for by a mean selenium concentration of 0.36 ug/L (Table 12d). The calculated selenium load at Vernalis for Water Year 1998 is 2,382 pounds higher than the calculated load at Crows Landing. This additional load, associated with 4.2 million acre-feet of additional water, can be accounted for by a mean selenium concentration of 0.2 ug/L.

In summary, tile drainage discharged from the DPA via the Grassland Bypass Project, accounted for 1 percent of the flow, 13 percent of the salt load, 34 percent of the boron load, and 65 percent of the selenium load in the SJR at Crows Landing. This tile drainage accounted for less than 1 percent of the flow, 8 percent of the salt load, 25 percent of the boron load, and 55 percent of the selenium load at Vernalis.

Annual discharges for the DPA, Grassland Watershed, SJR at Crows Landing, and SJR near Vernalis for Water Years 1986 through 1998 are shown in Figure 14. Water Year 1998 annual discharge at Crows Landing and Vernalis were the highest on record for the 13-year period presented. Water Year 1998 also had the highest discharge on record for the Grassland Watershed, but several years prior to Water Year 1998 had higher annual discharges from the DPA (Chilcott et al., 1999a). Annual salt loads were also the highest on record for the Grassland Watershed, Crows Landing and Vernalis (Figure 15). Annual salt load for the SJR near Vernalis was more than 50 percent higher in Water Year 1998 than in the prior wet water years of 1986, 1995, or 1996. By comparison, Crows Landing salt load was only slightly higher than prior wet years, suggesting that the source of much of the additional salt load in water year 1998 was downstream of Crows Landing. This pattern of salt loading was not repeated for the DPA; several years prior to Water Year 1998 (both wet and critically dry) had higher salt loads. Boron loads at Crows Landing, Vernalis, and from the DPA and Grassland Watershed were

Table 12. Water Year 1998 Load Summary and Comparison Between the Drainage Project Area, Grassland Watershed, and San Joaquin River at Crows Landing and near Vernalis

a. Summary of Annual Discharge and Loads

Site	Discharge (taf)	Selenium (pounds)	Boron (1000 pounds)	Salt (1000 tons)
Drainage Project Area (Grassland Bypass Project)	46	8,760	944	172
Grassland Watershed (Mud Slough plus Salt Slough)	378	9,630	1,860	626
Crows Landing	4,315	13,445	2,764	1,346
Vernalis	8,489	15,810	3,760	1,877

b. Difference in Discharges and Loads

This site...	...minus this site	Discharge (taf)	Selenium (pounds)	Boron (1000 pounds)	Salt (1000 tons)
Grassland Watershed	Drainage Project Area	332	870	916	454
Crows Landing	Drainage Project Area	4,269	4,685	1,820	1,174
	Grassland Watershed	3,937	3,815	904	720
Vernalis	Drainage Project Area	8,443	7,050	2,816	1,705
	Grassland Watershed	8,110	6,180	1,900	1,251
	Crows Landing	4,174	2,365	996	531

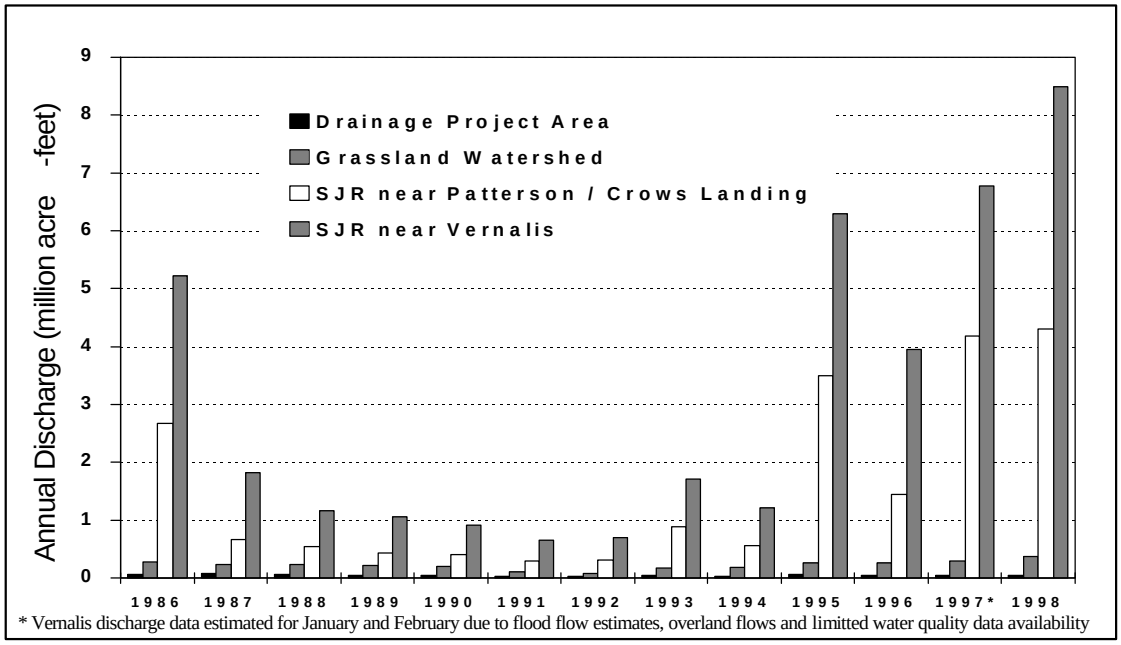
c. Percent Difference in Discharges and Loads

Percent Contribution to...	by...	Discharge	Selenium	Boron	Salt
Grassland Watershed	Drainage Project Area	12%	91%	51%	27%
	Grassland Watershed	100%	100%	100%	100%
	Unaccounted for	88%	9%	49%	73%
Calculated Crows Landing	Drainage Project Area	1%	65%	34%	13%
	Grassland Watershed	9%	72%	67%	46%
	Adjusted Crows Landing	100%	100%	100%	100%
	Unaccounted for	91%	28%	33%	54%
Vernalis	Drainage Project Area	1%	55%	25%	9%
	Grassland Watershed	4%	61%	49%	33%
	Adjusted Crows Landing	51%	85%	74%	72%
	Vernalis	100%	100%	100%	100%
	Unaccounted for	49%	15%	26%	28%

d. Concentration of Unreported Discharges

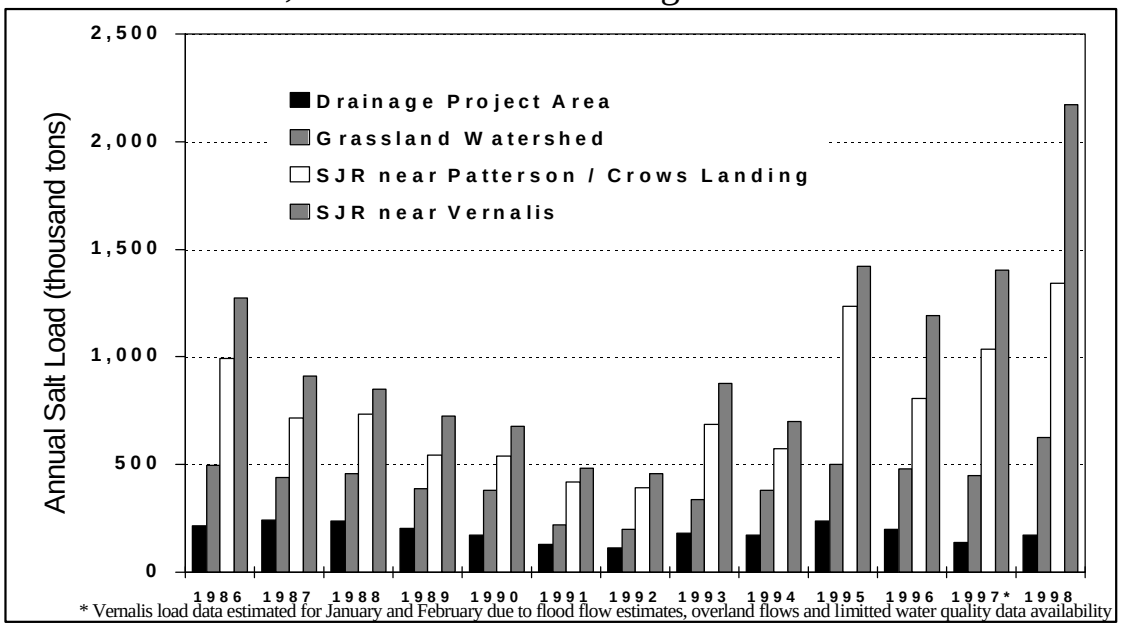
Site	Selenium (ug/L)	Boron (mg/L)	Salt (mg/L)
Grassland Watershed	0.96	1.01	1,004
Crows Landing	0.36	0.08	135
Vernalis	0.21	0.09	94

Figure 14. Annual Discharge from the Drainage Project Area, Grassland Watershed, and the San Joaquin River at Crows Landing and Vernalis, Water Years 1986 through 1998



* Vernalis discharge data estimated for January and February due to flood flow estimates, overland flows and limitted water quality data availability

Figure 15. Annual Salt Load from the Drainage Project Area, Grassland Watershed, and the San Joaquin River at Crows Landing and Vernalis, Water Years 1986 through 1998

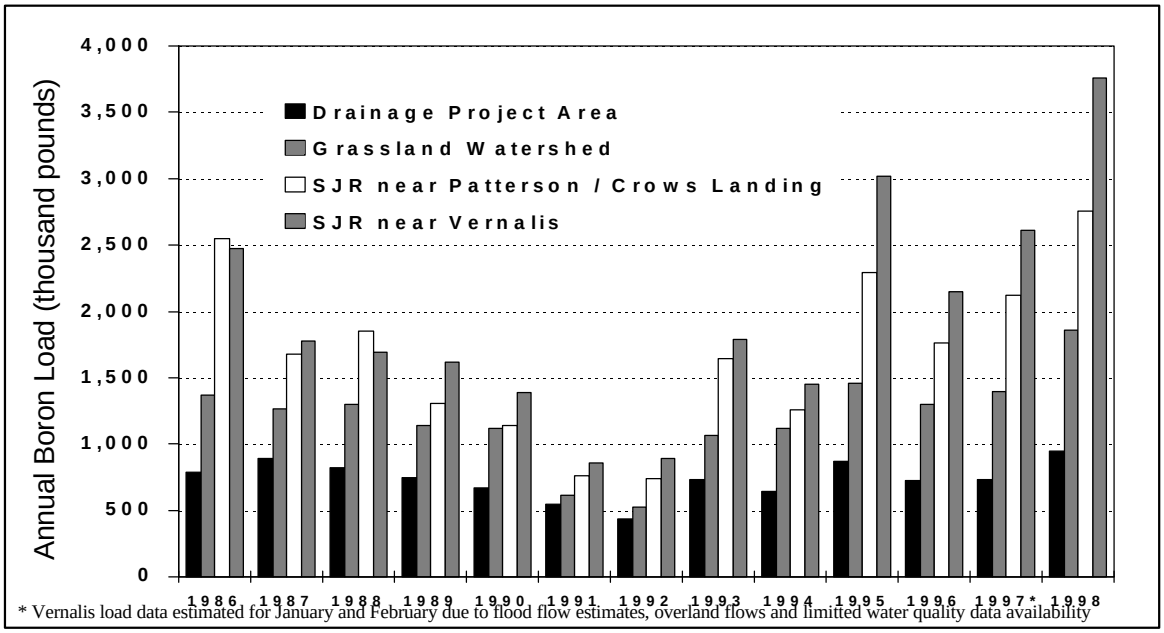


* Vernalis load data estimated for January and February due to flood flow estimates, overland flows and limitted water quality data availability

higher in Water Year 1998 than any prior year (Figure 16). Water Year 1998 selenium Loads at Crows Landing, Vernalis, and from the Grassland Watershed were the second highest on record, after Water Year 1995 (Figure 17). Selenium loads for the DPA were higher in six of the twelve years prior to Water Year 1998. See Chilcott et al (1999a) for a more complete discussion of selenium loading from the DPA.

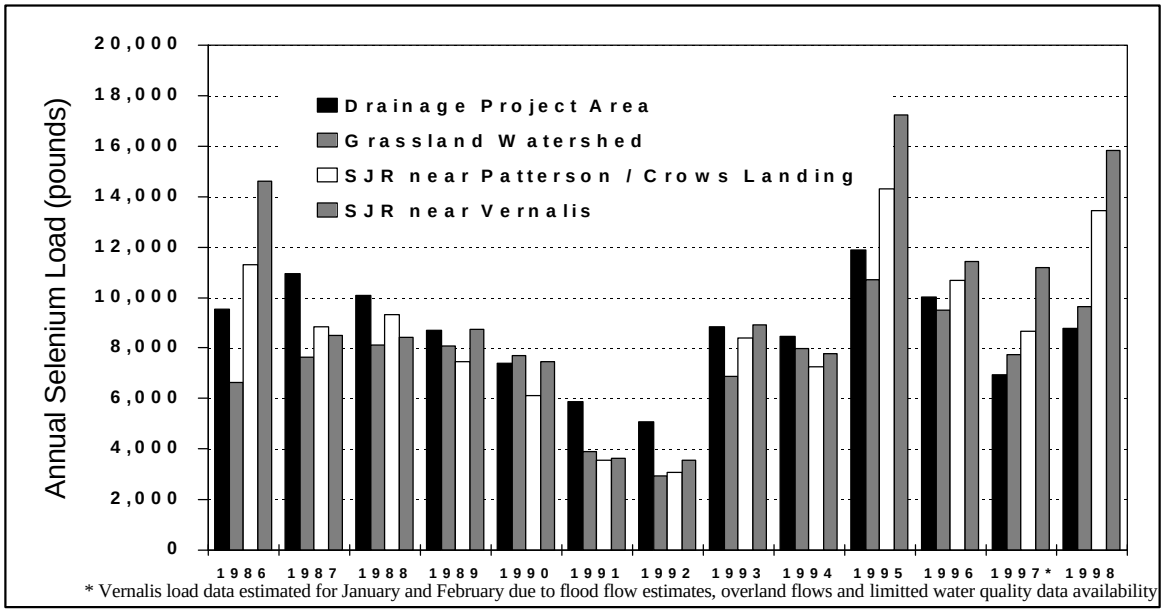
High annual discharge and loading at all sites is attributable to high rainfall and snow-melt in the watershed that started in February and continued intermittently through July of Water Year 1998. Loads of salt and boron in Water Year 1999 were the highest on record at the river sites and from the Grassland Watershed. Loading of salt and boron is closely tied to high rainfall and runoff because salt and boron are widely distributed within the basin. Most selenium loading is attributable to the DPA. Since selenium loading from the DPA is closely tied with management practices and irrigation rates, selenium loading is less easily correlated with rainfall and runoff. Selenium loads were higher in river sites and the DPA in several prior wet water years.

Figure 16. Annual Boron Load from the Drainage Project Area, Grassland Watershed, and the San Joaquin River at Crows Landing and Vernalis, Water Years 1986 through 1998



* Vernalis load data estimated for January and February due to flood flow estimates, overland flows and limitted water quality data availability

Figure 17. Annual Selenium Load from the Drainage Project Area, Grassland Watershed, and the San Joaquin River at Crows Landing and Vernalis, Water Years 1986 through 1998



* Vernalis load data estimated for January and February due to flood flow estimates, overland flows and limitted water quality data availability

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APPENDIX A
Grab Sample Water Quality Data
Water Year 1998

Legend of Abbreviations

EC = Electrical Conductivity
Se = Selenium
Mo = Molybdenum
Cr = Chromium
Cu = Copper
Ni = Nickel
Pb = Lead
Zn = Zinc
B = Boron
Cl = Chloride
SO4 = Sulfate
HDNS = Hardness
TSS = Total Suspended Solids
NA = Not Available

San Joaquin River at Lander Avenue (State Highway 165) (MER522)
Location: Latitude 37°17'43", Longitude 120°51'01". In NE 1/4, NE 1/4, Sec. 27, T.7S., R.10E. East Bank, 50 ft West of Lander Avenue (Highway 165), 2.3 mi. south of Stevinson. River Mile 132.9

		Temp		EC	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TSS
Date	Time	F	pH	umhos/cm	←			ug/L			→	←			mg/L			→
10/2/97	10:47	77	8.1	1420														
10/9/97	9:15	69	7.2	1530														
10/16/97	10:30	68	8.3	1420														
10/24/97	7:10	62	7.3	737														
10/30/97	10:50	62	7.8	354	<0.4	7	1.2	3.4	<5	<5	5.8	<0.05	44	19	71	NA	NA	
11/6/97	9:00	64	7.9	407														
11/14/97	11:50	60	8.0	731														
11/19/97	18:50	64	8.0	829														
11/25/97	10:40	63	6.9	1180														
12/5/97	11:05	55	8.5	605														
12/11/97	10:45	48	8.0	584														
12/18/97	12:40	51	7.2	909														
12/26/97	8:50	44	8.0	999														
1/2/98	11:09	51	7.4	1210														
1/8/98	11:50	54	8.0	1230														
1/15/98	11:30	52	7.2	207														
1/22/98	10:15	52	7.7	221														
1/29/98	7:40	55	7.6	399	0.5	2	4.4	5.8	5.6	<5	NA	0.11	40	29	120	26	13	
2/5/98	11:00	55	7.2	118														
2/11/98	11:50	54	7.1	192														
2/19/98	11:00	54	7.4	178														
2/26/98	11:00	57	7.9	192	1.1							0.06						
3/5/98	11:40	55	7.9	228														
3/12/98	10:25	60	7.7	180														16
3/19/98	16:30	72	7.5	163														28
3/26/98	9:55	65	7.8	138	0.6							<0.05						69
4/2/98	9:50	56	7.6	187														25
4/9/98	11:20	62	8.1	166														37
4/16/98	8:55	57	8.0	123														30
4/23/98	8:40	68	7.8	108														
4/30/98	7:55	69	6.3	103	<0.4							<0.05						20
5/7/98	9:25	64	7.3	104														27
5/14/98	7:45	59	8.0	101	0.5	1	2.2	1.7	<5	<5	NA	<0.05	5.2	7.4	32	8.4	2.8	26
5/21/98	7:20	63	7.6	80														30
5/28/98	12:28	61	7.2	76	<0.4							<0.05						29
6/4/98	8:50	67	7.9	71														24
6/11/98	12:15	68	7.7	85														
6/18/98	8:20	72	6.6	63														37
6/25/98	10:25	62	7.4	59	<0.4		1.8	1.5	<5	<5	NA	<0.05	3.2	3.7	21	5.5	1.7	22
7/2/98	7:50	71	7.1	51														32
7/9/98	11:00	79	7.5	46														
7/16/98	10:40	81	8.0	73														
7/23/98	10:45	80	7.7	143														
7/30/98	11:00	80	7.6	208	<0.4							0.05						
8/6/98	9:15	85	7.8	381														
8/13/98	17:10	86	8.3	292														
8/20/98	11:55	78	7.5	366														
8/27/98	10:25	75	7.5	296	<0.4	2						0.05						
9/3/98	7:15	79	7.7	307														
9/10/98	9:00	75	8.0	322														
9/17/98	10:00	76	8.4	158														
9/24/98	9:00	68	7.6	160	<0.4							<0.05						
Count		52	52	52	11	4	4	4	4	4	1	11	4	4	4	3	3	15
Min		44	6	46	<0.4	1	1	1.5	5.6	<5	5.8	<0.05	3.2	3.7	21	5.5	1.7	16
Max		86	8.5	1530	1.1	7	4	5.8	5.6	<5	5.8	0.11	44	29	120	26	13	69
Mean		65	7.6	394	0.4	3	2	3.1	3.3	2.5	5.8	<0.05	23.1	14.8	61	13.3	5.8	30
Geo Mean		64	7.6	244	<0.4	2	2	2.7	3.1	2.5	5.8	<0.05	13.1	11.1	49	10.6	4.0	28
Median		64	7.7	200	<0.4	2	2	2.6	2.5	2.5	5.8	<0.05	22.6	13.2	52	8.4	2.8	28

San Joaquin River at Freemont Ford (MER538)

Location: Latitude 37°18'34", Longitude 120°55'45". In NW 1/4, NW 1/4, Sec. 24, T.7S., R.9E. West Bank at Freemont Ford State Recreation Area, 50ft. south of Highway 140. 5.4 mi NE of Gustine. River Mi 125.2

Date	Time	Temp F	pH	EC umhos/cm	Se ug/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/2/97	1025	75	7.9	1040	1.3	0.46					
10/9/97	8:55	62	6.3	1160	0.8	0.58					
10/16/97	1005	69	7.8	1320	0.8	0.67					
10/24/97	6:50	60	6.5	1390	0.7	0.56					
10/30/97	1120	63	7.5	1190	0.6	0.48	NA	NA	NA	NA	NA
11/6/97	8:45	63	7.0	1320	0.6	0.61					
11/14/97	1130	59	7.8	1340	0.8	0.75					
11/19/97	1835	62	7.5	1550	0.7	0.88					
11/25/97	1020	64	7.8	2120	0.4	1.1					
12/5/97	1048	55	8.3	1120	1.1	0.68					
12/11/97	1035	48	8.0	1430	1.2	0.95					
12/18/97	1220	53	7.6	2140	1.3	1.2					
12/26/97	8:30	45	7.4	2480	1.3	1.1					
1/2/98	1050	54	7.4	2730	1.2	1.1					
1/8/98	1125	55	7.9	2830	0.8	1.2					
1/15/98	1115	52	7.2	281	0.5	0.07					
1/22/98	1000	52	7.7	533	0.6	0.32					
1/29/98	8:00	55	7.5	1440	0.7	0.84	230	220	320	66	38
2/5/98	1025	57	7.5	260	<0.4	0.10					
2/11/98	1125	54	7.3	207	0.6	0.06					
2/19/98	1035	54	7.2	246	0.4	<0.05					
2/26/98	1120	58	7.0	204	0.5	0.06					
3/5/98	1115	55	7.8	375	0.7	0.18					
3/12/98	1320	61	8.5	349	0.6	0.17					
3/19/98	1610	72	6.9	426	0.6	0.21					
3/26/98	9:35	64	7.9	211	0.6	0.12					
4/2/98	9:35	56	7.7	217	0.5	0.08					
4/9/98	1150	63	8.0	168	0.5	0.05					
4/16/98	8:30	55	8.5	124	<0.4	0.05					
4/23/98	8:15	66	7.3	108	<0.4	<0.05					
4/30/98	7:25	68	6.9	110	<0.4	<0.05					
5/7/98	9:10	65	7.3	104	0.5	<0.05					
5/14/98	7:20	58	7.9	105	<0.4	<0.05	5.5	7.5	33	8.6	2.8
5/21/98	7:05	63	7.5	91	<0.4	<0.05					
5/28/98	12:15	61	6.9	81	<0.4	<0.05					
6/4/98	8:35	67	7.1	80	<0.4	<0.05					
6/11/98	12:00	69	7.6	85	<0.4	<0.05					
6/18/98	8:05	72	7.3	72	<0.4	<0.05					
6/25/98	10:10	67	7.0	62	<0.4	<0.05	3.2	3.7	22	5.7	1.8
7/2/98	7:30	71	6.6	57	<0.4	<0.05					
7/9/98	10:45	79	7.0	48	0.4	<0.05					
7/16/98	11:00	82	7.6	80	<0.4	<0.05					
7/23/98	10:35	80	7.2	259	<0.4	0.08					
7/30/98	10:40	79	7.5	335	<0.4	0.12					
8/6/98	8:55	84	7.3	643	0.8	0.22					
8/13/98	10:45	82	6.8	561	0.7	0.22					
8/20/98	11:40	76	7.8	669	0.7	0.29					
8/27/98	10:10	76	6.7	660	0.7	0.27					
9/3/98	6:50	80	7.3	692	0.8	0.30					
9/10/98	8:50	72	7.1	816	0.7	0.32					
9/17/98	9:20	74	7.8	414	<0.4	0.15					
9/24/98	8:40	67	7.6	510	<0.4	0.16					
Count		52	52	52	52	52	3	3	3	3	3
Min		45	6.3	48	<0.4	<0.05	3	3.7	22	5.7	1.8
Max		84	8.5	2830	1.3	1.2	230	220	320	66	38
Mean		64	7.4	708	0.6	0.33	80	77	125	27	14
Geo Mean		64	7.4	386	0.5	0.15	16	18	61	14.8	5.8
Median		63	7.5	395	0.6	0.17	6	7.5	33	8.6	2.8

San Joaquin River at Hills Ferry Road (STC512)

Location: Latitude 37°20'33", Longitude 120°58'38". In NE 1/4, SE 1/4, NE 1/4, Sec. 9, T.7S., R.9E. West Bank, 0.9 mi. SE of Hills Ferry Road at an abandoned tallow factory, immediately upstream of Merced River inflow, 3.3 mi. NE of Newman. River Mile 118.1

Date	Time	Temp F	pH	EC umhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TSS	CO3	HCO3
					ug/L													mg/L		
10/2/97	10:05	76	7.8	1150	3.0							0.85								
10/9/97	11:15	67	7.7	1560	7.8							1.6								
10/16/97	9:30	68	7.5	1390	4.2							1.3								
10/24/97	9:25	60	8.0	1700	5.5							1.4								
10/30/97	12:05	65	7.5	1730	4.9	11	NA	NA	NA	NA	NA	1.5	NA	NA	NA	NA	NA			
11/6/97	11:15	66	7.1	1700	5.0							1.4								
11/14/97	10:50	58	7.7	1570	4.1							1.4								
11/19/97	16:40	60	7.7	1640	3.3							1.3								
11/25/97	10:00	64	7.7	1950	3.0	8						1.5								
12/5/97	9:59	56	8.2	1390	1.7							1.1								
12/11/97	9:55	47	7.9	1570	3.4							1.3								
12/18/97	11:55	52	7.6	2020	2.1							1.5								
12/26/97	13:00	48	7.8	2450	3.7	11						1.8								
1/2/98	10:30	54	7.4	2710	3.3							1.9								
1/8/98	11:00	54	8.0	2460	5.1							1.8								
1/15/98	10:50	52	7.1	669	2.0							0.46								
1/22/98	9:12	52	7.7	692	1.0							0.50								
1/28/98	16:25	56	7.8	1620	2.4	4	5.5	5.4	8.6	<5	NA	1.3	230	260	360	70	45			
2/5/98	11:25	54	7.4	669	2.0							0.56								
2/11/98	10:30	NA	NA	778	1.9							0.67	84	130	190	40	22		<1	120
2/19/98	9:45	54	7.5	917	3.0							0.79								
2/26/98	13:40	58	7.6	918	2.8							0.79								
3/5/98	10:10	56	7.8	857	2.8							0.72	87	153	200	43	21	18	<1	130
3/12/98	9:50	62	7.9	835	3.3							0.70						31		
3/19/98	15:35	72	7.3	888	3.1							0.71						32		
3/26/98	9:05	66	7.9	793	3.3							0.64						18		
4/2/98	9:10	56	7.5	793	3.1							0.62						21		
4/9/98	12:20	66	8.0	681	2.4							0.58						25		
4/16/98	9:30	59	7.7	611	3.3							0.54								
4/22/98	19:15	74	8.0	520	2.5							0.43						25		
4/30/98	10:20	68	7.2	405	2.1	2						0.30						26		
5/7/98	8:45	64	7.0	460	2.4							0.35						33		
5/14/98	11:20	64	7.2	467	2.2	3	2.8	2.4	<5	<5	NA	0.36	48	83	110	25	11	31	<1	66
5/21/98	11:30	67	8.2	432	2.6							0.37						34		
5/28/98	11:43	61	7.5	391	2.2							0.31						27		
6/4/98	12:30	72	6.7	295	1.5							0.23						30		
6/11/98	11:10	69	7.4	295	1.6							0.22						31		
6/18/98	11:40	78	6.9	261	1.4							0.20						44		
6/24/98	10:45	76	7.2	224	1.1		2.6	1.9	<5	<5	NA	0.18	20	35	55	13	5.2		<1	41
7/2/98	11:35	65	7.4	208	0.9							0.18								
7/9/98	9:40	79	7.1	233	1.0							0.21								
7/16/98	14:20	87	8.5	282	1.2							0.23								
7/23/98	9:45	80	7.5	517	1.9							0.42								
7/30/98	10:00	78	7.5	741	3.2							0.66								
8/6/98	13:20	88	7.8	1130	5.2							1.0								
8/13/98	17:50	88	8.2	1080	4.4							1.0								
8/20/98	10:55	74	7.6	1170	5.0							1.1								
8/27/98	9:25	74	7.6	1170	5.0	4						1.1								
9/3/98	11:20	82	7.2	1170	5.2							1.1								
9/10/98	12:55	76	8.1	1200	5.1							1.1								
9/17/98	12:55	78	7.1	843	5.3							0.88								
9/24/98	13:00	73	NA	909	3.8							0.78								
Count		51	50	52	52	7	3	3	3	3	0	52	5	5	5	5	5	15	4	4
Min		47	6.7	208	0.9	2	2.6	1.9	8.6	0		0.18	20	35	55	13	5.2	18	<1	41
Max		88	8.5	2710	7.8	11	5.5	5.4	8.6	0		1.9	230	260	360	70	45	44	<1	130
Mean		66	7.6	1020	3.1	6	3.6	3.2	4.5	2.5		0.84	94	132	183	38	21	28	<1	89
Geo Mean		65	7.6	836	2.8	5	3.4	2.9	3.8	2.5		0.69	69	108	153	33	16	28	<1	81
Median		66	7.6	873	3.0	4	2.8	2.4	2.5	2.5		0.75	84	130	190	40	21	30	<1	93

San Joaquin River at Crows Landing Road (STC504)

Location: Latitude 37°25'55", Longitude 121°00'42". In Section 8 T.6S., R.8E. East Bank, 100 yards south

Date	Time	Temp F	pH	EC umhos/cm	Se	Diss.Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TSS	CO3	HCO3	T.Alk	Na
					ug/L								mg/L										
10/02/1997	9:40	76	7.8	960	1.3								0.57										
10/09/1997	11:35	66	7.9	1020	3.4								0.86										
10/16/1997	9:00	66	7.4	1000	2.5								0.77										
10/24/1997	9:50	61	8.1	1050	2.4								0.75										
10/30/1997	12:40	64	6.7	1170	3.0		8	2	3.8	<5	<5	6.5	0.85	150	190	250	NA	NA					
11/06/1997	11:35	66	7.7	1160	2.7								0.86										
11/14/1997	10:25	58	7.8	1150	2.6								0.90										
11/19/1997	17:50	60	6.7	1160	2.0								0.80										
11/25/1997	9:25	63	7.7	1360	1.9		6						0.92										
12/05/1997	9:25	56	8.4	1120	1.4								0.83										
12/11/1997	12:55	NA	7.8	1240	2.7								0.98										
12/18/1997	10:45	52	7.6	1510	1.6								1.0										
12/26/1997	13:30	49	7.8	1660	1.6		7						1.0										
01/02/1998	13:30	54	7.5	1700	1.5								1.0										
01/08/1998	10:20	54	7.9	1570	3.1								1.1										
01/15/1998	10:15	52	7.3	616	1.6								0.38										
01/22/1998	8:53	52	7.7	542	0.9								0.36										
01/28/1998	16:00	56	7.7	961	1.4		3	2.6	4.4	<5	<5	NA	0.74	110	140	210	43	26					
02/04/1998	12:15	55	7.3	382	1.0								0.21										
02/11/1998	12:15	54	7.0	335	0.8								0.20										
02/19/1998	9:50	54	7.5	399	0.8								0.26										
02/26/1998	9:20	59	7.7	431	1.1								0.27										
03/05/1998	12:00	56	7.8	541	1.4								0.37										
03/12/1998	9:40	59	7.8	572	1.9	1.8							0.39						22				
03/19/1998	9:20	66	8.1	636	1.9	2.0							0.45						43				
03/26/1998	12:05	64	8.2	435	1.7								0.30						110				
04/02/1998	8:45	56	7.5	450	1.4	1.3							0.27						17				
04/09/1998	8:40	65	7.9	421	1.1	0.9							0.22						28				
04/16/1998	0:00	57	7.7	265	1.0	1.0							0.17						17				
04/22/1998	9:50	72	7.8	288	1.0	0.9							0.18										
04/30/1998	18:45	72	7.5	236	0.9	0.8	2						0.13						24				
05/07/1998	10:55	62	7.3	244	1.0	1.1							0.14						26				
05/14/1998	7:55	62	7.5	252	1.0	0.9	2	2.3	2.8	<5	<5	NA	0.15	22	35	63	15	6	29				
05/21/1998	12:00	68	8.3	211	1.0	1.1							0.14						38				
05/28/1998	11:55	61	7.5	220	1.5	0.9							0.13						36				
06/04/1998	13:30	71	7.1	179	0.8	0.8							0.10						31				
06/11/1998	10:40	69	7.3	190	0.8	0.7							0.11						33				
06/18/1998	12:30	74	7.1	159	0.7	0.7							0.10						30				
06/24/1998	11:45	65	7.2	135	0.5	0.5		1.9	2.2	<5	<5	NA	0.08	10	14	35	9	3	30	<1	34	28	12
07/02/1998	11:53	72	7.3	133	0.5	0.5							0.09										
07/09/1998	9:20	78	7.1	136	0.7	0.4							0.09										
07/16/1998	14:40	81	8.2	169	0.6	0.6							0.11										
07/23/1998	9:15	77	7.1	288	1.0	0.8							0.19										
07/30/1998	9:25	78	7.5	433	1.3	1.6							0.31										
08/06/1998	13:55	83	7.8	654	2.6	2.6							0.47										
08/13/1998	18:25	84	7.6	709	2.3	2.3							0.54										
08/20/1998	9:20	64	7.7	724	2.5	2.4							0.59										
08/27/1998	9:00	72	7.8	607	2.1	2.0	2						0.45										
09/03/1998	12:00	75	7.8	582	2.2	2.2							0.46										
09/10/1998	13:15	72	7.9	511	1.5	1.8							0.37										
09/17/1998	13:15	73	7.5	440	1.9	1.9							0.35										
09/24/1998	13:20	69	NA	398	1.1	0.9							0.24										
Count		51	51	52	52	28	7	4	4	4	4	1	52	4	4	4	3	3	15	1	1	1	1
Min		49	6.7	133	0.5	0.4	2	1.9	2.2	<5	<5	6.5	0.08	10	14	35	9	3	17	<1	34	28	12
Max		84	8.4	1700	3.4	2.6	8	2.6	4.4	<5	<5	6.5	1.1	150	190	250	43	26	110	<1	34	28	12
Mean		65	7.6	648	1.6	1.3	4	2.2	3.3	2.5	2.5	6.5	0.45	73	95	140	22	12	34	<1	34	28	12
Geo Mean		64	7.6	506	1.4	1.1	4	2.2	3.2	2.5	2.5	6.5	0.34	44	60	104	18	8	31	<1	34	28	12
Median		64	7.7	526	1.4	1.0	3	2.2	3.3	2.5	2.5	6.5	0.37	66	88	137	15	6	30	<1	34	28	12

San Joaquin River at Las Palmas Launching Facility (Patterson) (STC507)
Location: Latitude 37°29'52", Longitude 121°04'54". In SW 1/4, NW 1/4, SW 1/4, Sec. 15, T.5S., R.8E. West Bank, 0.3 mi. N of Patterson Bridge at NE corner of Las Palmas Launching Facility parking lot, 3.2 mi. NE of Patterson. River Mile

Date	Time	Temp F	pH	EC umhos/cm	Se ug/L	Mo mg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L	TSS mg/L
10/2/97	9:21	75	7.5	1040	1.2		0.53						
10/9/97	13:10	68	7.7	919	3.0		0.66						
10/16/97	8:30	66	6.9	1040	2.1		0.70						
10/24/97	10:25	62	8.0	949	1.8		0.63						
10/30/97	13:05	64	7.4	1200	2.5		0.78						
11/6/97	13:10	65	7.9	1210	2.6		0.85						
11/14/97	10:00	59	7.7	1410	2.6		0.85						
11/19/97	15:45	61	7.4	1170	1.8		0.74						
11/25/97	8:50	63	7.5	1370	1.4		0.86						
12/5/97	9:00	56	8.0	1130	1.4		0.79						
12/11/97	9:15	48	7.8	1410	3.5		0.97						
12/18/97	10:10	53	7.6	1520	1.6		0.99						
12/26/97	13:55	49	7.6	1700	1.4		1.0						
1/2/98	14:20	55	7.7	1700	1.4		0.97						
1/8/98	9:55	54	7.8	1530	2.8		1.0						
1/15/98	9:20	52	7.1	767	1.6		0.43						
1/28/98	15:35	56	7.5	956	1.5		0.73	120	150	210	43	26	
2/5/98	12:00	54	7.4	361	0.9		0.20						
2/11/98	9:15	54	7.3	388	0.8		0.22						
2/19/98	8:55	54	7.5	414	0.9		0.26						
2/26/98	12:45	57	7.3	498	1.2		0.31						
3/5/98	9:00	56	7.6	579	1.4		0.39						
3/12/98	8:45	58	7.7	575	1.9		0.39						24
3/19/98	16:00	68	8.1	688	2.0		0.46						68
3/26/98	13:05	65	7.8	500	1.8		0.33						83
4/2/98	8:10	55	7.4	438	1.4		0.28						23
4/9/98	10:20	64	7.8	356	1.1		0.23						31
4/16/98	10:15	61	7.6	300	1.0		0.19						27
4/22/98	18:20	73	7.8	270	1.0		0.17						
4/30/98	11:25	71	7.6	232	0.9		0.13						30
5/7/98	7:10	62	7.1	248	1.0		0.13						40
5/13/98	18:45	60	7.8	238	0.8	2	0.12	20	29	63	15	6.3	40
5/21/98	12:15	66	7.9	224	1.0		0.14						31
5/28/98	10:06	62	7.3	219	1.0		0.10						32
6/4/98	14:05	72	7.5	190	0.8		0.11						25
6/11/98	9:40	70	7.4	263	0.8		0.12						31
6/18/98	13:05	76	7.3	155	0.6		0.09						41
6/24/98	12:16	68	7.3	138	0.6		0.09	11	17	39	9.5	3.6	45
7/2/98	12:20	75	7.4	139	0.5		0.09						
7/9/98	8:20	74	7.1	137	0.8		0.08						
7/16/98	14:55	82	7.9	180	0.6		0.11						
7/23/98	8:15	78	7.3	329	1.0		0.20						
7/30/98	8:55	77	7.3	462	1.3		0.31						
8/6/98	14:20	84	7.8	771	2.5		0.50						
8/13/98	19:00	82	8.0	815	2.2		0.55						
8/20/98	9:00	64	7.6	804	2.2		0.56						
8/27/98	8:40	74	7.7	672	2.0	2	0.45						
9/2/98	19:31	79	7.5	675	2.5		0.49						
9/10/98	13:40	74	7.8	656	1.7		0.44						
9/17/98	13:55	76	7.6	494	1.8		0.36						
9/24/98	13:42	69	NA	545	1.3		0.32						
9/30/98	18:55	70	7.3	541	0.8		0.32						
Count		52	51	52	52	2	52	3	3	3	3	3	15
Min		48	6.9	137	0.5	2	0.08	11	17	39	10	4	23
Max		84	8.1	1700	3.5	2	1.0	120	150	210	43	26	83
Mean		65	7.6	683	1.5	2	0.44	50	65	104	23	12	38
Geo Mean		65	7.6	536	1.3	2	0.33	30	42	80	18	8	35
Median		65	7.6	560	1.4	2	0.38	20	29	63	15	6	31

San Joaquin River at Maze Blvd. (State Highway 132) (STC510)
Location: Latitude 37°38'31", Longitude 121°13'40". In SW 1/4, NW 1/4, SW 1/4, Sec. 29, T.3S., R.7E.
West Bank, 400 ft S of Maze Blvd Bridge upstream of Blewett Drain, River Mile 77.2

Date	Time	Temp F	pH	EC umhos/cm	Se ug/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Ca mg/L	Mg mg/L
10/2/97	8:20	74	7.1	751	0.7	0.32					
10/9/97	13:50	67	7.9	474	0.9	0.28					
10/16/97	7:55	64	6.4	653	1.4	0.37					
10/24/97	10:55	62	8.1	634	0.8	0.36					
10/30/97	14:00	64	7.2	823	1.5	0.46	NA	NA	NA	NA	NA
11/6/97	13:45	64	8.1	820	1.1	0.47					
11/14/97	9:30	58	7.7	847	1.1	0.48					
11/19/97	NA	NA	NA	NA	NA	NA					
11/25/97	8:15	62	7.3	1040	1.0	0.58					
12/5/97	8:32	56	7.7	984	0.9	0.59					
12/11/97	8:45	48	7.7	967	2.1	0.66					
12/18/97	9:30	52	7.6	1110	1.1	0.65					
12/26/97	14:20	49	7.7	1200	1.0	0.64					
1/2/98	NA	NA	NA	NA	NA	NA					
1/8/98	9:20	54	7.5	1100	1.4	0.62					
1/15/98	8:40	52	7.2	579	1.1	0.29					
1/22/98	7:55	52	7.1	314	0.6	0.17					
1/28/98	14:45	55	7.5	470	0.7	0.32	51	62	110	23	13
2/5/98	13:05	55	7.4	241	0.6	0.12					
2/11/98	8:30	52	7.2	320	0.8	0.17					
2/19/98	8:25	52	7.4	347	0.8	0.67					
2/26/98	8:25	53	7.6	364	0.8	0.21					
3/5/98	8:20	54	7.7	387	0.9	0.23					
3/12/98	8:10	56	7.5	406	1.4	0.25					
3/19/98	17:00	64	7.7	NA	1.2	0.29					
3/26/98	8:45	60	7.7	405	1.3	0.27					
4/2/98	7:35	54	7.6	295	1.0	0.16					
4/9/98	9:20	62	7.4	281	1.0	0.18					
4/16/98	10:45	59	7.4	239	0.8	0.14					
4/22/98	17:20	70	7.2	236	0.8	0.13					
4/29/98	18:55	70	7.2	212	0.7	0.11					
5/7/98	6:40	60	7.1	228	0.9	0.11					
5/14/98	17:55	59	7.8	197	0.5	0.09	15	22	55	13	5.6
5/21/98	12:50	65	7.7	201	0.8	0.11					
5/28/98	9:10	60	7.0	185	1.0	0.10					
6/4/98	14:40	69	7.5	165	0.6	0.09					
6/11/98	9:05	67	7.3	184	0.7	0.10					
6/18/98	13:45	73	7.5	135	0.4	0.07					
6/24/98	3:00	75	7.8	122	0.5	0.07	9.6	13	35	8.4	3.5
7/2/98	13:00	73	7.4	137	0.4	0.08					
7/9/98	7:46	76	6.9	141	0.5	0.08					
7/16/98	15:30	79	7.8	145	0.5	0.08					
7/23/98	7:40	74	7.3	226	0.7	0.12					
7/30/98	8:20	76	6.7	351	0.8	0.21					
8/6/98	15:40	80	7.8	428	1.5	0.24					
8/13/98	19:35	79	8.0	528	1.2	0.29					
8/20/98	8:35	72	7.5	636	1.3	0.34					
8/27/98	8:10	72	7.7	504	1.3	0.29					
9/2/98	18:55	79	6.9	524	1.9	0.34					
9/10/98	14:20	72	8.1	321	0.8	0.19					
9/17/98	15:10	72	7.8	320	0.8	0.20					
9/24/98	14:55	70	NA	364	0.9	0.18					
9/30/98	17:20	69	7.2	296	0.4	0.23					
Count		51	50	50	51	51	3	3	3	3	3
Min		48	6.4	122	0.4	0.07	9.6	13	35	8.4	3.5
Max		80	8.1	1200	2.1	0.67	51	62	110	23	13
Mean		64	7.5	457	0.9	0.27	25	32	67	15	7.4
Geo Mean		63	7.5	375	0.9	0.22	19	26	60	14	6.3
Median		64	7.5	358	0.9	0.23	15	22	55	13	5.6

San Joaquin River at Airport Way (SJC501)
Location: Latitude 37°40'32", Longitude 121°15'51". In SE 1/4, SW 1/4, NW 1/4, Sec. 13, T.3S., R.6E.
West Bank, south of Airport Way Bridge, 3.2 miles NE of Vernalis River Mile 72.3.

Date	Time	Temp F	pH	EC umhos/cm	Se	Mo	Cr	Cu ug/L	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TSS mg/L	CO3	HCO3	T.Alk	Na	K
10/2/97	8:12	73	7.1	546	0.5							0.21											
10/9/97	14:10	66	7.9	432	0.8							0.25											
10/16/97	7:35	62	6.1	380	0.7							0.20											
10/24/97	11:15	62	8.1	529	0.6							0.29											
10/30/97	14:15	64	7.2	669	1.0	4	NA	NA	NA	NA	NA	0.35	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA
11/6/97	14:00	64	8.0	679	0.8							0.37											
11/14/97	9:00	58	8.5	708	0.8							0.38											
11/19/97	14:50	62	7.1	740	0.9							0.42											
11/25/97	7:50	60	6.8	875	0.8	4						0.47											
12/5/97	8:09	56	7.1	862	0.8							0.51											
12/11/97	8:15	48	7.8	853	1.5							0.57											
12/18/97	9:05	52	7.3	977	1.2							0.55											
12/26/97	14:45	50	7.7	983	0.8	5						0.52											
1/2/98	15:20	54	7.6	961	0.8							0.48											
1/8/98	9:05	54	7.4	943	1.3							0.50											
1/15/98	8:05	50	6.8	438	0.9							0.21											
1/22/98	7:30	52	7.0	294	0.5							0.15											
1/28/98	13:50	55	7.2	402	0.6	2	4.4	1.8	<5	<5	NA	0.26	45	52	97	20	11						
2/5/98	13:20	44	7.4	236	0.6							0.10											
2/11/98	7:55	52	7.0	307	0.7							0.18	24	42	90	20	10		<1	60	49	27	5.1
2/19/98	7:55	54	7.2	325	0.6							0.19											
2/26/98	8:10	53	6.8	337	0.5							0.19											
3/5/98	7:45	55	7.4	351	0.8							0.21	31	52	92	21	9.8		<1	71	58	30	2.8
3/12/98	7:40	56	6.6	431	1.2							0.26						24					
3/19/98	17:20	64	8.1	419	1.3							0.24						40					
3/26/98	8:30	58	7.6	396	1.1							0.23						36					
4/2/98	7:05	53	7.6	303	0.9							0.17						420*					
4/9/98	9:00	62	6.9	297	0.9							0.17						25					
4/16/98	11:00	59	7.5	230	0.6							0.13						30					
4/22/98	17:00	73	7.8	222	0.7							0.11						NA					
4/29/98	17:30	71	6.9	242	0.7							0.13						32					
5/7/98	6:15	60	6.9	231	0.9							0.11						47					
5/13/98	17:30	60	7.7	216	0.5	2	2.5	2.1	<5	<5	NA	0.10	18	23	61	14	6.2	30	<1	56	46	19	1.6
5/21/98	13:05	63	7.8	221	0.5							0.12						46					
5/28/98	8:51	62	7.7	200	0.8							0.10						44					
6/4/98	15:05	NA	7.3	174	0.7							0.09						34					
6/11/98	8:45	66	7.3	191	0.6							0.09						48					
6/18/98	2:10	75	6.6	141	0.3							0.07						31					
6/24/98	3:20	73	7.6	142	0.5		2.5	2.3	<5	<5	NA	0.07	11	14	41	9.8	4.1	32	<1	41	34	12	1.3
7/2/98	13:25	74	7.6	166	0.4							0.10											
7/9/98	7:25	74	7.4	150	0.4							0.08											
7/16/98	15:50	79	7.6	148	0.4							0.09											
7/23/98	7:15	72	6.9	208	0.6							0.11											
7/30/98	8:00	74	7.1	277	0.6							0.17											
8/6/98	15:55	77	7.0	324	0.7							0.17											
8/13/98	19:55	76	8.0	374	0.7							0.19											
8/20/98	8:10	68	7.8	419	0.8							0.21											
8/27/98	7:50	68	7.5	358	0.8	1						0.19											
9/2/98	18:30	74	7.5	363	1.0							0.22											
9/10/98	14:55	76	8.1	262	0.5							0.15											
9/17/98	15:25	68	7.5	239	0.5							0.16											
9/24/98	15:05	68	NA	265	0.5							0.11											
9/30/98	17:00	68	6.2	233	<0.4							0.09											
Count		52	52	53	53	6	3	3	3	3	0	53	5	5	5	5	5.0	14	4	4	4	4	4.0
Min		44	6.1	141	<0.4	1.0	2.5	1.8	<5	<5		0.07	11	14	41	10	4	24	<1	41	34	12	1.3
Max		79	8.5	983	1.5	5	4.4	2.3	<5	<5		0.57	45	52	97	21	11	48	<1	71	58	30	5.1
Mean		63	7.4	414	0.7	3	3.1	2.1	2.5	2.5		0.22	26	37	76	17	8	36	1	57	47	22	3
Geo Mean		62	7.3	353	0.7	3	3.0	2.1	2.5	2.5		0.19	23	33	73	16	8	35	1	56	46	21	2
Median		62	7.4	325	0.7	3	2.5	2.1	2.5	2.5		0.19	24	42	90	20	10	33	1	58	48	23	2

Merced River at Hatfield Park (MER546)

Location: Latitude 37°20'59", Longitude 120°57'28". Township/Range/Section: NE 1/4, SW 1/4, SW 1/4, Sec. 2, T7S, R.9E. (DWR# 7S/9E-2N). 3.5 mi. NE of Newman. Approximately 0.5 mi. upstream of confluence with the San Joaquin River (River Mile 118.2).

	Temp		EC	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TDS	CO3	HCO3	T.Alk	Na	K
Date	**F**	**pH**	**umhos/cm**	ug/L													mg/L					
1/28/98	56	8.0	90	<0.4							<0.05	5.1	5.9	32	7.5	3.2						
4/30/98	60	7.7	78	<0.4							<0.05											
6/24/98	65	7.0	52	<0.4		<1.0	<1.0	<5.0	<5.0	NA	<0.05	2.2	3.1	21	5.2	1.9	71	<1	26	21	2.4	<1
Count	3	3.0	3	2	0	1	1	1	1	0	3	2	2	2	2	2	1	1	1	1	1	1
Min	56	7.0	52	<0.4		<1	<1	<5	<5		<0.05	2.2	3.1	21	5.2	1.9	71	<1	26	21	2.4	<1
Max	65	8.0	90	<0.4		<1	<1	<5	<5		<0.05	5.1	5.9	32	7.5	3.2	71	<1	26	21	2.4	<1
Mean	60	7.6	73	<0.4		<1	<1	<5	<5		<0.05	3.7	4.5	27	6.4	2.6	71	<1	26	21	2.4	<1
Geo Mean	60	7.5	71	<0.4		<1	<1	<5	<5		<0.05	3.3	4.3	26	6.2	2.5	71	<1	26	21	2.4	<1
Median	60	7.7	78	<0.4		<1	<1	<5	<5		<0.05	3.7	4.5	27	6.4	2.6	71	<1	26	21	2.4	<1

Tuolumne River at Shiloh Fishing Access (STC513)

Location: Latitude 37 ° 36 ' 11", Longitude 121° 07 ' 54". Left bank of the Tuolumne River, under Shiloh Road Bridge, approximately 7 miles upstream of the confluence with the San Joaquin River (River mile 83.7).

	Temp		EC	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TDS	CO3	HCO3	T.Alk	Na	K
Date	**F**	**pH**	**umhos/cm**	ug/L													mg/L					
1/28/98	56	7.8	64.8	<0.4							<0.05	2.8	3.7	25	5.6	2.6						
4/29/98	62	7.6	67.6	<0.4							<0.05											
6/24/98	68	8.3	48.9	<0.4		<1.0	<1.0	<5.0	<5.0	NA	<0.05	2.5	2.7	19	4.3	1.9	58	<1	23	17	2.3	<1
Count	3	3.0	3	3	0	1	1	1	1	0	3	2	2	2	2	2	1	1	1	1	1	1
Min	56	7.6	48.9	<0.4		<1	<1	<5	<5		<0.05	2.5	2.7	19	4.3	1.9	58	<1	23	17	2.3	<1
Max	68	8.3	67.6	<0.4		<1	<1	<5	<5		<0.05	2.8	3.7	25	5.6	2.6	58	<1	23	17	2.3	<1
Mean	62	7.9	60.4	<0.4		<1	<1	<5	<5		<0.05	2.7	3.2	22	5.0	2.3	58	<1	23	17	2.3	<1
Geo Mean	62	7.9	59.8	<0.4		<1	<1	<5	<5		<0.05	2.6	3.2	22	4.9	2.2	58	<1	23	17	2.3	<1
Median	62	7.8	64.8	<0.4		<1	<1	<5	<5		<0.05	2.7	3.2	22	5.0	2.3	58	<1	23	17	2.3	<1

Stanislaus River at Caswell Park (STC514)

Location: Latitude 37°42', Longitude 121°10'. Right bank of the Stanislaus River approximately seven miles upstream of the confluence with the San Joaquin River (River mile 74.9).

	Temp		EC	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS	Ca	Mg	TDS	CO3	HCO3	T.Alk	Na	K
Date	**F**	**pH**	**umhos/cm**	ug/L													mg/L					
1/28/98	55	7.7	102	<0.4							<0.05	3.1	5.1	43	8.3	5.4						
4/29/98	62	7.0	94	<0.4							<0.05											
6/24/98	64	7.5	72	<0.4		<1.0	<1.0	<5.0	<5.0	NA	<0.05	2.4	3.4	30	7.4	2.9	66	<1	38	31	3	<1
Count	3	3.0	3	3	0	1	1	1	1	0	3	2	2	2	2	2	1	1	1	1	1	1
Min	55	7.0	72	<0.4		<1	<1	<5	<5		<0.05	2.4	3.4	30	7.4	2.9	66	<1	38	31	3	<1
Max	64	7.7	102	<0.4		<1	<1	<5	<5		<0.05	3.1	5.1	43	8.3	5.4	66	<1	38	31	3	<1
Mean	60	7.4	89.3	<0.4		<1	<1	<5	<5		<0.05	2.8	4.3	37	7.9	4.2	66	<1	38	31	3	<1
Geo Mean	60	7.4	88.4	<0.4		<1	<1	<5	<5		<0.05	2.7	4.2	36	7.8	4.0	66	<1	38	31	3	<1
Median	62	7.5	94	<0.4		<1	<1	<5	<5		<0.05	2.8	4.3	37	7.9	4.2	66	<1	38	31	3	<1

APPENDIX B
Automated Daily Composite Water Quality Data

Legend of Abbreviations

EC = Electrical Conductivity
Se = Selenium
B = Boron
NA = Not Available

San Joaquin River at Crows Landing Road: Turlock Sportsman Club (STC504S)
Location: Latitude 37°25'55", Longitude 121°00'42". In Section 8 T.6S., R.8E. East Bank, 100 yards south of Crows Landing Road Bridge, 4.2 miles northeast of Crows Landing. River Mile 107.1
AUTOSAMPLER DATA : 12 hour daily composite samples - WY 98

Date	EC mmhos/cm	Se mg/L	B mg/L
10/1/97	950	1.3	0.59
10/2/97	898	1.4	0.57
10/3/97	930	1.8	0.84
10/4/97	1060	2.9	0.62
10/5/97	932	2.2	0.73
10/6/97	865	2.2	0.66
10/7/97	874	2.8	0.65
10/8/97	893	3.1	0.71
10/9/97	999	4.1	0.80
10/10/97	1070	3.4	0.82
10/11/97	1170	3.1	0.87
10/12/97	1130	3.6	0.85
10/13/97	972	3.0	0.71
10/14/97	1000	3.2	0.76
10/15/97	1020	2.6	0.72
10/16/97	1050	2.4	0.74
10/17/97	1090	2.4	0.81
10/18/97	1120	2.4	0.85
10/19/97	1090	2.8	0.85
10/20/97	1070	2.3	0.84
10/21/97	1100	2.1	0.87
10/22/97	1030	1.8	0.77
10/23/97	951	2.0	0.70
10/24/97	1030	2.4	0.75
10/25/97	1040	2.5	0.72
10/26/97	1110	2.6	0.77
10/27/97	1140	2.6	0.80
10/28/97	1140	3.5	0.82
10/29/97	1170	2.7	0.85
10/30/97	1160	2.4	0.89
10/31/97	1170	2.7	0.87
11/1/97	1110	2.5	0.79
11/2/97	950	1.9	0.64
11/3/97	972	1.9	0.65
11/4/97	1070	2.2	0.71
11/5/97	1120	2.2	0.75
11/6/97	1160	2.2	0.84
11/7/97	1450	2.8	0.84
11/8/97	1210	2.2	0.84
11/9/97	1180	2.4	0.81
11/10/97	1210	2.3	0.83
11/11/97	1180	2.1	0.79
11/12/97	1150	2.0	0.75
11/13/97	NA	NA	NA
11/14/97	NA	NA	NA
11/15/97	NA	NA	NA
11/16/97	NA	NA	NA
11/17/97	NA	NA	NA
11/18/97	NA	NA	NA
11/19/97	NA	NA	NA
11/20/97	1160	2.2	0.79
11/21/97	1200	2.0	0.84
11/22/97	1280	2.1	0.88
11/23/97	1300	2.1	0.90
11/24/97	1310	2.3	0.90
11/25/97	1320	2.0	0.90
11/26/97	1380	1.9	0.93
11/27/97	1350	1.9	0.92
11/28/97	1310	1.8	0.88
11/29/97	1290	1.9	0.90
11/30/97	1280	2.0	0.94
12/1/97	1260	1.7	0.89
12/2/97	1280	1.6	0.89
12/3/97	1280	1.4	0.89
12/4/97	1200	1.2	0.81
12/5/97	1120	1.3	0.80
12/6/97	1130	1.3	0.81
12/7/97	1170	1.8	0.87
12/8/97	1190	1.9	0.88
12/9/97	1220	2.1	0.96
12/10/97	1250	3.3	0.97
12/11/97	1240	3.2	0.97
12/12/97	1270	2.8	1.0
12/13/97	1330	2.6	1.1
12/14/97	1370	2.2	1.1
12/15/97	1370	1.2	0.98
12/16/97	1420	1.6	1.1
12/17/97	1450	1.9	1.1
12/18/97	1480	1.6	1.1
12/19/97	1570	1.4	1.1
12/20/97	1620	1.4	1.1
12/21/97	1650	1.5	1.1
12/22/97	1650	1.3	1.1
12/23/97	1640	1.2	1.1
12/24/97	1670	1.5	1.1
12/25/97	1710	2.0	1.1
12/26/97	1700	1.5	1.1
12/27/97	1670	2.0	1.1
12/28/97	1580	2.2	1.1
12/29/97	1690	2.0	1.1
12/30/97	1690	1.8	1.0
12/31/97	1680	1.8	1.0
1/1/98	1680	1.6	1.0
1/2/98	1660	1.5	1.0
1/3/98	1770	1.9	1.1
1/4/98	1790	2.4	1.1
1/5/98	1770	2.6	1.1
1/6/98	1780	2.8	1.1
1/7/98	1590	2.8	1.1
1/8/98	1630	3.1	1.1
1/9/98	1690	2.4	1.1
1/10/98	1710	2.4	1.1
1/11/98	1660	1.9	1.0
1/12/98	1560	1.8	0.96
1/13/98	1300	2.2	0.81
1/14/98	909	1.7	0.53
1/15/98	770	1.4	0.47
1/16/98	577	1.5	0.39

WY 97 Crows Landing Sigma Autosampler Data continued:

Date	EC mmhos/cm	Se mg/L	B mg/L
1/17/98	402	0.9	0.25
1/18/98	398	1.0	0.26
1/19/98	380	0.9	0.25
1/20/98	453	1.0	0.31
1/21/98	506	1.1	0.34
1/22/98	524	0.9	0.35
1/23/98	598	0.8	0.40
1/24/98	673	1.0	0.45
1/25/98	778	1.1	0.52
1/26/98	863	1.2	0.61
1/27/98	923	1.5	0.67
1/28/98	959	1.6	0.70
1/29/98	987	1.5	0.69
1/30/98	980	1.3	0.65
1/31/98	608	1.1	NA
2/1/98	414	1.1	0.25
2/2/98	478	1.2	0.30
2/3/98	446	1.8	0.24
2/4/98	378	1.2	0.19
2/5/98	323	0.9	0.21
2/6/98	374	1.2	0.25
2/7/98	352	1.0	0.20
2/8/98	339	1.0	0.18
2/9/98	354	1.5	0.20
2/10/98	364	1.1	0.21
2/11/98	357	1.0	0.21
2/12/98	356	1.1	0.20
2/13/98	366	1.1	0.21
2/14/98	374	1.1	0.23
2/15/98	388	1.1	0.24
2/16/98	420	1.1	0.27
2/17/98	424	1.1	0.27
2/18/98	402	1.1	0.25
2/19/98	410	1.0	0.25
2/20/98	425	1.2	0.27
2/21/98	438	1.2	0.28
2/22/98	468	1.4	0.29
2/23/98	450	1.2	0.28
2/24/98	434	1.1	0.26
2/25/98	424	1.1	0.26
2/26/98	436	1.3	0.27
2/27/98	417	1.4	0.26
2/28/98	426	1.3	0.30
3/1/98	451	1.6	0.33
3/2/98	501	1.3	0.27
3/3/98	427	1.5	0.36
3/4/98	524	1.5	0.40
3/5/98	557	1.4	0.39
3/6/98	540	1.6	0.40
3/7/98	560	1.7	0.42
3/8/98	564	2.0	0.44
3/9/98	NA	NA	NA
3/10/98	NA	NA	NA
3/11/98	NA	NA	NA
3/12/98	NA	NA	NA
3/13/98	NA	NA	NA
3/14/98	NA	NA	NA
3/15/98	NA	NA	NA
3/16/98	NA	NA	NA
3/17/98	NA	NA	NA
3/18/98	NA	NA	NA
3/19/98	NA	NA	NA
3/20/98	636	2.1	0.49
3/21/98	642	2.3	0.51
3/22/98	668	2.3	0.51
3/23/98	656	2.3	0.52
3/24/98	670	2.4	0.52
3/25/98	663	2.4	0.51
3/26/98	468	1.7	0.34
3/27/98	462	1.9	0.32
3/28/98	331	1.1	0.22
3/29/98	302	1.1	0.19
3/30/98	327	1.2	0.23
3/31/98	354	1.3	0.24
4/1/98	387	1.3	0.25
4/2/98	418	1.3	0.27
4/3/98	422	1.4	0.28
4/4/98	406	1.3	0.26
4/5/98	387	1.2	0.24
4/6/98	388	1.2	0.23
4/7/98	380	1.2	0.23
4/8/98	372	1.2	0.22
4/9/98	339	1.0	0.20
4/10/98	352	1.0	0.21
4/11/98	346	1.1	0.21
4/12/98	302	0.9	0.18
4/13/98	281	0.9	0.16
4/14/98	286	1.0	0.17
4/15/98	288	1.0	0.17
4/16/98	282	1.1	0.17
4/17/98	287	1.0	0.17
4/18/98	293	1.1	0.18
4/19/98	285	1.0	0.17
4/20/98	268	1.0	0.16
4/21/98	274	0.8	0.16
4/22/98	273	0.8	0.16
4/23/98	268	0.9	0.16
4/24/98	263	0.9	0.16
4/25/98	265	1.0	0.19
4/26/98	244	0.8	0.14
4/27/98	253	0.9	0.15
4/28/98	241	0.9	0.14
4/29/98	239	0.9	0.14
4/30/98	232	0.8	0.13
5/1/98	232	1.1	0.14
5/2/98	229	1.2	0.13
5/3/98	224	0.9	0.13
5/4/98	233	1.2	0.13
5/5/98	238	1.1	0.13
5/6/98	232	1.0	0.13
5/7/98	245	1.3	0.14
5/8/98	250	1.7	0.15
5/9/98	247	1.2	0.15
5/10/98	233	1.2	0.13
5/11/98	211	0.9	0.11
5/12/98	201	1.0	0.11
5/13/98	222	0.9	0.12

WY 97 Crows Landing Sigma Autosampler Data continued:

Date	EC mmhos/cm	Se mg/L	B mg/L
5/14/98	243	1.2	0.14
5/15/98	261	1.2	0.16
5/16/98	279	1.4	0.19
5/17/98	250	1.1	0.16
5/18/98	246	1.1	0.15
5/19/98	246	1.3	0.16
5/20/98	238	1.2	0.16
5/21/98	222	1.3	0.15
5/22/98	217	1.1	0.15
5/23/98	222	1.3	0.15
5/24/98	220	1.2	0.14
5/25/98	219	1.2	0.14
5/26/98	215	0.9	0.14
5/27/98	206	1.0	0.13
5/28/98	210	0.9	0.13
5/29/98	211	1.2	0.14
5/30/98	208	0.9	0.13
5/31/98	218	1.1	0.14
6/1/98	219	1.1	0.14
6/2/98	205	0.9	0.13
6/3/98	187	0.8	0.11
6/4/98	181	0.8	0.10
6/5/98	184	0.8	0.11
6/6/98	182	0.6	0.10
6/7/98	181	0.5	0.09
6/8/98	180	0.5	0.10
6/9/98	186	0.6	0.11
6/10/98	201	0.9	0.12
6/11/98	189	0.7	0.11
6/12/98	180	0.7	0.10
6/13/98	188	0.8	0.11
6/14/98	NA	NA	NA
6/15/98	NA	NA	NA
6/16/98	161	0.5	0.09
6/17/98	152	0.6	0.08
6/18/98	161	0.6	0.09
6/19/98	151	0.6	0.08
6/20/98	149	0.7	0.09
6/21/98	144	0.6	0.08
6/22/98	141	0.6	0.07
6/23/98	143	0.8	0.08
6/24/98	138	0.6	0.07
6/25/98	135	0.5	0.07
6/26/98	135	0.6	0.08
6/27/98	134	0.5	0.08
6/28/98	142	0.6	0.08
6/29/98	146	0.5	0.09
6/30/98	143	0.5	0.09
7/1/98	144	0.5	0.08
7/2/98	144	0.6	0.08
7/3/98	146	0.5	0.08
7/4/98	155	0.6	0.12
7/5/98	148	0.6	0.10
7/6/98	138	0.6	0.09
7/7/98	135	0.8	0.10
7/8/98	137	0.5	0.09
7/9/98	135	0.5	0.09
7/10/98	130	0.6	0.08
7/11/98	126	0.5	0.08
7/12/98	138	0.5	0.09
7/13/98	152	0.6	0.10
7/14/98	171	0.6	0.11
7/15/98	175	0.7	0.11
7/16/98	172	0.7	0.11
7/17/98	178	0.6	0.11
7/18/98	192	0.7	0.12
7/19/98	203	0.8	0.13
7/20/98	227	0.9	0.15
7/21/98	251	1.0	0.16
7/22/98	286	1.2	0.18
7/23/98	303	1.0	0.19
7/24/98	320	1.1	0.23
7/25/98	359	1.1	0.25
7/26/98	390	1.4	0.28
7/27/98	354	1.4	0.25
7/28/98	347	1.3	0.26
7/29/98	380	1.5	0.28
7/30/98	NA	NA	NA
7/31/98	NA	NA	NA
8/1/98	558	1.7	0.41
8/2/98	609	1.9	0.46
8/3/98	632	2.0	0.49
8/4/98	641	2.0	0.51
8/5/98	642	2.1	0.46
8/6/98	653	2.2	0.48
8/7/98	710	2.3	0.51
8/8/98	790	2.3	0.56
8/9/98	876	2.5	0.59
8/10/98	809	2.5	0.60
8/11/98	742	2.2	0.54
8/12/98	726	2.4	0.56
8/13/98	719	2.4	0.55
8/14/98	738	2.2	0.54
8/15/98	729	2.1	0.54
8/16/98	743	2.1	0.55
8/17/98	729	1.9	0.55
8/18/98	809	2.2	0.60
8/19/98	902	2.6	0.68
8/20/98	741	2.3	0.57
8/21/98	673	2.3	0.50
8/22/98	641	2.1	0.46
8/23/98	623	1.8	0.45
8/24/98	596	2.1	0.43
8/25/98	587	1.8	0.42
8/26/98	595	2.0	0.44
8/27/98	606	2.1	0.45
8/28/98	608	2.2	0.44
8/29/98	605	1.9	0.45
8/30/98	619	2.2	0.48
8/31/98	606	2.1	0.48
9/1/98	604	2.3	0.48
9/2/98	584	2.3	0.47
9/3/98	586	2.3	0.45
9/4/98	587	2.0	0.43
9/5/98	571	1.9	0.41
9/6/98	538	1.9	0.40
9/7/98	506	1.7	0.38
9/8/98	474	1.8	0.35

WY 97 Crows Landing Sigma Autosampler Data continued:

Date	EC mmhos/cm	Se mg/L	B mg/L
9/9/98	486	2.0	0.35
9/10/98	502	1.8	0.35
9/11/98	534	1.8	0.37
9/12/98	551	1.9	0.40
9/13/98	526	2.2	0.39
9/14/98	492	1.8	0.38
9/15/98	474	1.8	0.38
9/16/98	451	1.7	0.34
9/17/98	444	2.0	0.34
9/18/98	431	1.8	0.32
9/19/98	395	1.6	0.29
9/20/98	373	1.8	0.28
9/21/98	369	0.5	0.25
9/22/98	410	1.0	0.28
9/23/98	450	1.1	0.30
9/24/98	428	0.9	0.29
9/25/98	436	1.0	0.30
9/26/98	442	0.9	0.30
9/27/98	377	0.6	0.24
9/28/98	333	0.4	0.22
9/29/98	387	0.6	0.27
9/30/98	398	0.7	0.28
Count	343	343	342
Min	126	0.4	0.07
Max	1790	4.1	1.1
Mean	649	1.5	0.45
Geo Mean	499	1.4	0.33
Median	468	1.4	0.34

San Joaquin River at Las Palmas Launching Facility (Patterson) (STC507)

Location: Latitude 37°29'52", Longitude 121°04'54". In SW 1/4, NW 1/4, SW 1/4, Sec. 15, T.5S., R.8E. West Bank, 0.

N of Patterson Bridge at Las Palmas Launching Facility parking lot, 3.2 mi. NE of Patterson. River Mile 9

AUTOSAMPLER DATA : 12 hour daily composite samples - WY 98

Date	EC mmhos/cm	Se mg/L	B mg/L
4/10/98	348	1.1	0.22
4/11/98	347	1.2	0.23
4/12/98	313	1.1	0.19
4/13/98	287	0.9	0.17
4/14/98	288	1.0	0.18
4/15/98	291	1.1	0.18
4/16/98	292	1.1	0.18
4/17/98	293	1.1	0.18
4/18/98	298	1.2	0.19
4/19/98	299	1.2	0.19
4/20/98	282	1.1	0.17
4/21/98	278	0.9	0.17
4/22/98	272	1.0	0.17
4/23/98	274	1.0	0.17
4/24/98	266	1.0	0.17
4/25/98	274	1.0	0.17
4/26/98	270	0.9	0.16
4/27/98	253	0.9	0.16
4/28/98	249	0.9	0.15
4/29/98	239	0.9	0.15
4/30/98	236	0.9	0.14
5/1/98	231	0.9	0.14
5/2/98	242	0.8	0.14
5/3/98	238	0.8	0.14
5/4/98	237	0.8	0.14
5/5/98	245	0.7	0.14
5/6/98	244	0.9	0.13
5/7/98	243	0.8	0.14
5/8/98	258	1.1	0.15
5/9/98	260	1.0	0.15
5/10/98	250	0.9	0.14
5/11/98	227	0.6	0.12
5/12/98	203	0.5	0.11
5/13/98	215	0.6	0.11
5/14/98	262	0.7	0.13
5/15/98	286	0.9	0.15
5/16/98	305	1.2	0.19
5/17/98	284	1.3	0.16
5/18/98	267	0.9	0.15
5/19/98	260	1.1	0.15
5/20/98	258	1.1	0.15
5/21/98	248	1.1	0.15
5/22/98	239	1.1	0.14
5/23/98	240	1.0	0.14
5/24/98	244	1.2	0.14
5/25/98	229	1.0	0.13
5/26/98	232	1.1	0.13
5/27/98	220	0.9	0.12
5/28/98	218	1.0	0.12
5/29/98	227	0.9	0.13
5/30/98	214	1.0	0.13
5/31/98	228	1.0	0.13
6/1/98	228	1.1	0.14
6/2/98	215	1.0	0.13
6/3/98	199	0.9	0.12
6/4/98	189	0.8	0.10
6/5/98	197	0.7	0.11
6/6/98	196	0.8	0.11
6/7/98	185	0.5	0.09
6/8/98	183	0.5	0.09
6/9/98	190	0.6	0.10
6/10/98	210	0.9	0.12
6/11/98	211	0.8	0.13
6/12/98	197	0.8	0.12
6/13/98	206	0.9	0.13
6/14/98	192	0.8	0.11
6/15/98	175	0.6	0.09
6/16/98	162	0.5	0.09
6/17/98	166	0.6	0.10
6/18/98	156	0.6	0.09
6/19/98		0.8	0.09
6/20/98	153	0.7	0.09
6/21/98	156	0.7	0.09
6/22/98	146	0.6	0.08
6/23/98	143	0.5	0.08
6/24/98	142	0.6	0.08
6/25/98	140	0.4	0.09
6/26/98	142	0.6	0.09
6/27/98	141	0.4	0.09
6/28/98	144	0.4	0.09
6/29/98	151	0.3	0.09
6/30/98	152	0.5	0.09
7/1/98	147	0.6	0.08
7/2/98	151	0.4	0.09
7/3/98	151	0.4	0.08
7/4/98	163	0.6	0.10
7/5/98	165	0.8	0.10
7/6/98	146	0.5	0.09
7/7/98	137	0.4	0.09
7/8/98	139	0.2	0.09
7/9/98	139	0.4	0.09
7/10/98	142	0.6	0.10
7/11/98	140	0.5	0.09
7/12/98	145	0.6	0.09
7/13/98	155	0.6	0.10
7/14/98	170	0.7	0.11
7/15/98	185	0.7	0.12
7/16/98	186	0.7	0.12
7/17/98	189	0.7	0.12
7/18/98	203	0.7	NA
7/19/98	214	0.8	NA
7/20/98	221	0.8	0.14
7/21/98	247	0.9	0.15
7/22/98	285	1.0	0.18
7/23/98	306	1.0	0.20
7/24/98	323	1.1	0.22
7/25/98	353	1.1	0.23
7/26/98	409	1.6	0.28
7/27/98	405	1.4	0.26
7/28/98	361	1.3	0.25
7/29/98	387	1.5	0.28
7/30/98	422	1.5	0.30
7/31/98	523	1.7	0.37
8/1/98	550	1.9	0.37
8/2/98	577	1.9	0.38
8/3/98	630	2.1	0.44
8/4/98	626	2.1	0.44
8/5/98	660	2.5	0.46
8/6/98	649	2.6	0.45
Count	118	119	117
Min	137	0.2	0.08
Max	660	2.6	0.46
Mean	251	0.9	0.15
Geo Mean	233	0.8	0.14
Median	232	0.9	0.14

APPENDIX C

4-Day Running Average Selenium Concentrations in the San Joaquin River at Crows Landing

Legend of Abbreviations

EC = Electrical Conductivity
Se = Selenium
B = Boron
NA = Not Available

San Joaquin River at Crows Landing Road: Turlock Sportsman Club (STC504S)
Location: Latitude 37°25'55", Longitude 121°00'42". In Section 8 T.6S., R.8E. West Bank, 100 yards south of Crows Landing Road Bridge, 4.2 miles northeast of Crows Landing. River Mile 107.1
AUTOSAMPLER DATA : 4 DAY RUNNING AVERAGE BASED 0N DAILY COMPOSITE SAMPLES - WY 98

Date	EC mmhos/cm	Se mg/L	B mg/L
10/1/97			
10/2/97			
10/3/97			
10/4/97	960	1.9	0.66
10/5/97	955	2.1	0.69
10/6/97	947	2.3	0.71
10/7/97	933	2.5	0.67
10/8/97	891	2.6	0.69
10/9/97	908	3.0	0.71
10/10/97	959	3.3	0.75
10/11/97	1032	3.4	0.80
10/12/97	1092	3.5	0.84
10/13/97	1085	3.3	0.81
10/14/97	1069	3.2	0.80
10/15/97	1032	3.1	0.76
10/16/97	1010	2.8	0.73
10/17/97	1040	2.6	0.76
10/18/97	1070	2.4	0.78
10/19/97	1087	2.5	0.81
10/20/97	1092	2.5	0.84
10/21/97	1094	2.4	0.85
10/22/97	1069	2.2	0.83
10/23/97	1034	2.0	0.80
10/24/97	1025	2.1	0.77
10/25/97	1011	2.2	0.74
10/26/97	1032	2.4	0.74
10/27/97	1078	2.5	0.76
10/28/97	1106	2.8	0.78
10/29/97	1138	2.9	0.81
10/30/97	1151	2.8	0.84
10/31/97	1160	2.8	0.86
11/1/97	1153	2.6	0.85
11/2/97	1099	2.4	0.80
11/3/97	1051	2.2	0.74
11/4/97	1025	2.1	0.70
11/5/97	1027	2.0	0.69
11/6/97	1080	2.1	0.74
11/7/97	1198	2.4	0.79
11/8/97	1234	2.4	0.82
11/9/97	1251	2.4	0.83
11/10/97	1263	2.4	0.83
11/11/97	1197	2.3	0.82
11/12/97	1180	2.2	0.80
11/13/97	NA	NA	NA
11/14/97	NA	NA	NA
11/15/97	NA	NA	NA
11/16/97	NA	NA	NA
11/17/97	NA	NA	NA
11/18/97	NA	NA	NA
11/19/97	NA	NA	NA
11/20/97	NA	NA	NA
11/21/97	NA	NA	NA
11/22/97	NA	NA	NA
11/23/97	1235	2.1	0.85
11/24/97	1271	2.1	0.88
11/25/97	1300	2.1	0.90
11/26/97	1325	2.1	0.91
11/27/97	1338	2.0	0.91
11/28/97	1338	1.9	0.91
11/29/97	1330	1.9	0.91
11/30/97	1307	1.9	0.91
12/1/97	1286	1.8	0.90
12/2/97	1279	1.8	0.91
12/3/97	1278	1.7	0.90
12/4/97	1258	1.5	0.87
12/5/97	1223	1.4	0.85
12/6/97	1185	1.3	0.83
12/7/97	1156	1.4	0.82
12/8/97	1152	1.6	0.84
12/9/97	1177	1.8	0.88
12/10/97	1206	2.3	0.92
12/11/97	1224	2.6	0.95
12/12/97	1245	2.8	0.98
12/13/97	1273	3.0	1.0
12/14/97	1303	2.7	1.0
12/15/97	1335	2.2	1.0
12/16/97	1371	1.9	1.1
12/17/97	1400	1.7	1.1
12/18/97	1429	1.6	1.1
12/19/97	1481	1.6	1.1
12/20/97	1532	1.6	1.1
12/21/97	1581	1.5	1.1
12/22/97	1622	1.4	1.1
12/23/97	1639	1.4	1.1
12/24/97	1652	1.4	1.1
12/25/97	1668	1.5	1.1
12/26/97	1681	1.6	1.1
12/27/97	1689	1.7	1.1
12/28/97	1664	1.9	1.1
12/29/97	1660	1.9	1.1
12/30/97	1658	2.0	1.1
12/31/97	1659	2.0	1.1
1/1/98	1684	1.8	1.0
1/2/98	1676	1.7	1.0
1/3/98	1695	1.7	1.0
1/4/98	1724	1.8	1.1
1/5/98	1748	2.1	1.1
1/6/98	1777	2.4	1.1
1/7/98	1733	2.6	1.1
1/8/98	1693	2.8	1.1
1/9/98	1674	2.8	1.1
1/10/98	1656	2.7	1.1
1/11/98	1674	2.4	1.1
1/12/98	1655	2.1	1.0
1/13/98	1556	2.1	0.97
1/14/98	1356	1.9	0.83
1/15/98	1133	1.8	0.69
1/16/98	888	1.7	0.55

WY 97 Crows Landing 4-day running average continued:

Date	EC µmhos/cm	Se µg/L	B mg/L
1/17/98	665	1.4	0.41
1/18/98	537	1.2	0.34
1/19/98	439	1.1	0.29
1/20/98	408	1.0	0.27
1/21/98	434	1.0	0.29
1/22/98	466	1.0	0.31
1/23/98	520	1.0	0.35
1/24/98	575	1.0	0.39
1/25/98	643	1.0	0.43
1/26/98	728	1.0	0.50
1/27/98	809	1.2	0.56
1/28/98	881	1.3	0.63
1/29/98	933	1.4	0.67
1/30/98	962	1.5	0.68
1/31/98	884	1.4	NA
2/1/98	747	1.3	NA
2/2/98	620	1.2	NA
2/3/98	487	1.3	NA
2/4/98	429	1.3	0.25
2/5/98	406	1.2	0.24
2/6/98	380	1.3	0.22
2/7/98	357	1.1	0.21
2/8/98	347	1.0	0.21
2/9/98	355	1.2	0.21
2/10/98	352	1.1	0.20
2/11/98	354	1.1	0.20
2/12/98	358	1.2	0.21
2/13/98	361	1.1	0.21
2/14/98	363	1.1	0.21
2/15/98	371	1.1	0.22
2/16/98	387	1.1	0.24
2/17/98	402	1.1	0.25
2/18/98	409	1.1	0.26
2/19/98	414	1.1	0.26
2/20/98	415	1.1	0.26
2/21/98	419	1.1	0.26
2/22/98	435	1.2	0.27
2/23/98	445	1.3	0.28
2/24/98	448	1.2	0.28
2/25/98	444	1.2	0.27
2/26/98	436	1.2	0.27
2/27/98	428	1.2	0.26
2/28/98	426	1.3	0.27
3/1/98	433	1.4	0.29
3/2/98	449	1.4	0.29
3/3/98	451	1.4	0.32
3/4/98	476	1.5	0.34
3/5/98	502	1.4	0.36
3/6/98	512	1.5	0.39
3/7/98	545	1.6	0.40
3/8/98	555	1.7	0.41
3/9/98	NA	NA	NA
3/10/98	NA	NA	NA
3/11/98	NA	NA	NA
3/12/98	NA	NA	NA
3/13/98	NA	NA	NA
3/14/98	NA	NA	NA
3/15/98	NA	NA	NA
3/16/98	NA	NA	NA
3/17/98	NA	NA	NA
3/18/98	NA	NA	NA
3/19/98	NA	NA	NA
3/20/98	NA	NA	NA
3/21/98	NA	NA	NA
3/22/98	NA	NA	NA
3/23/98	651	2.3	0.51
3/24/98	659	2.3	0.52
3/25/98	664	2.3	0.52
3/26/98	614	2.2	0.47
3/27/98	566	2.1	0.42
3/28/98	481	1.8	0.35
3/29/98	391	1.4	0.27
3/30/98	356	1.3	0.24
3/31/98	329	1.2	0.22
4/1/98	343	1.2	0.23
4/2/98	372	1.3	0.25
4/3/98	395	1.3	0.26
4/4/98	408	1.3	0.27
4/5/98	408	1.3	0.26
4/6/98	401	1.2	0.25
4/7/98	390	1.2	0.24
4/8/98	382	1.2	0.23
4/9/98	370	1.1	0.22
4/10/98	361	1.1	0.22
4/11/98	352	1.1	0.21
4/12/98	335	1.0	0.20
4/13/98	320	1.0	0.19
4/14/98	304	1.0	0.18
4/15/98	289	0.9	0.17
4/16/98	284	1.0	0.17
4/17/98	286	1.0	0.17
4/18/98	288	1.0	0.17
4/19/98	287	1.0	0.17
4/20/98	283	1.0	0.17
4/21/98	280	1.0	0.17
4/22/98	275	0.9	0.16
4/23/98	271	0.9	0.16
4/24/98	270	0.8	0.16
4/25/98	267	0.9	0.17
4/26/98	260	0.9	0.16
4/27/98	256	0.9	0.16
4/28/98	251	0.9	0.16
4/29/98	244	0.9	0.14
4/30/98	241	0.9	0.14
5/1/98	236	0.9	0.14
5/2/98	233	1.0	0.14
5/3/98	229	1.0	0.13
5/4/98	230	1.1	0.13
5/5/98	231	1.1	0.13
5/6/98	232	1.1	0.13
5/7/98	237	1.2	0.13
5/8/98	241	1.3	0.14
5/9/98	244	1.3	0.14
5/10/98	244	1.3	0.14
5/11/98	235	1.2	0.14
5/12/98	223	1.1	0.13
5/13/98	217	1.0	0.12

WY 97 Crows Landing 4-day running average continued:

Date	EC mmhos/cm	Se mg/L	B mg/L
5/14/98	219	1.0	0.12
5/15/98	232	1.1	0.13
5/16/98	251	1.2	0.15
5/17/98	258	1.2	0.16
5/18/98	259	1.2	0.17
5/19/98	255	1.2	0.17
5/20/98	245	1.1	0.16
5/21/98	238	1.2	0.16
5/22/98	231	1.2	0.16
5/23/98	225	1.2	0.15
5/24/98	220	1.2	0.15
5/25/98	220	1.2	0.15
5/26/98	219	1.1	0.14
5/27/98	215	1.1	0.14
5/28/98	213	1.0	0.14
5/29/98	211	1.0	0.14
5/30/98	209	1.0	0.13
5/31/98	212	1.0	0.14
6/1/98	214	1.1	0.14
6/2/98	213	1.0	0.14
6/3/98	207	1.0	0.13
6/4/98	198	0.9	0.12
6/5/98	189	0.8	0.11
6/6/98	184	0.7	0.11
6/7/98	182	0.7	0.10
6/8/98	182	0.6	0.10
6/9/98	182	0.6	0.10
6/10/98	187	0.6	0.11
6/11/98	189	0.7	0.11
6/12/98	189	0.7	0.11
6/13/98	190	0.8	0.11
6/14/98	NA	NA	NA
6/15/98	NA	NA	NA
6/16/98	NA	NA	NA
6/17/98	NA	NA	NA
6/18/98	NA	NA	NA
6/19/98	156	0.6	0.08
6/20/98	153	0.6	0.08
6/21/98	151	0.6	0.08
6/22/98	146	0.6	0.08
6/23/98	144	0.7	0.08
6/24/98	142	0.6	0.07
6/25/98	139	0.6	0.07
6/26/98	138	0.6	0.07
6/27/98	136	0.6	0.07
6/28/98	137	0.6	0.08
6/29/98	139	0.6	0.08
6/30/98	141	0.5	0.08
7/1/98	144	0.5	0.08
7/2/98	144	0.5	0.08
7/3/98	144	0.5	0.08
7/4/98	147	0.6	0.09
7/5/98	148	0.6	0.10
7/6/98	147	0.6	0.10
7/7/98	144	0.6	0.10
7/8/98	140	0.6	0.09
7/9/98	136	0.6	0.09
7/10/98	134	0.6	0.09
7/11/98	132	0.5	0.09
7/12/98	132	0.5	0.09
7/13/98	137	0.6	0.09
7/14/98	147	0.6	0.09
7/15/98	159	0.6	0.10
7/16/98	168	0.7	0.11
7/17/98	174	0.7	0.11
7/18/98	179	0.7	0.11
7/19/98	186	0.7	0.12
7/20/98	200	0.8	0.13
7/21/98	218	0.8	0.14
7/22/98	242	1.0	0.16
7/23/98	267	1.0	0.17
7/24/98	290	1.1	0.19
7/25/98	317	1.1	0.21
7/26/98	343	1.1	0.24
7/27/98	356	1.2	0.25
7/28/98	363	1.3	0.26
7/29/98	368	1.4	0.27
7/30/98	NA	NA	NA
7/31/98	NA	NA	NA
8/1/98	NA	NA	NA
8/2/98	NA	NA	NA
8/3/98	NA	NA	NA
8/4/98	610	1.9	0.47
8/5/98	631	2.0	0.48
8/6/98	642	2.1	0.49
8/7/98	662	2.2	0.49
8/8/98	699	2.2	0.50
8/9/98	757	2.3	0.54
8/10/98	796	2.4	0.57
8/11/98	804	2.4	0.57
8/12/98	788	2.4	0.57
8/13/98	749	2.4	0.56
8/14/98	731	2.3	0.55
8/15/98	728	2.3	0.55
8/16/98	732	2.2	0.55
8/17/98	735	2.0	0.55
8/18/98	753	2.1	0.56
8/19/98	796	2.2	0.60
8/20/98	795	2.2	0.60
8/21/98	781	2.4	0.59
8/22/98	739	2.3	0.55
8/23/98	670	2.1	0.50
8/24/98	633	2.1	0.46
8/25/98	612	2.0	0.44
8/26/98	600	1.9	0.44
8/27/98	596	2.0	0.44
8/28/98	599	2.0	0.44
8/29/98	604	2.1	0.45
8/30/98	610	2.1	0.46
8/31/98	610	2.1	0.46
9/1/98	609	2.1	0.47
9/2/98	603	2.2	0.48
9/3/98	595	2.3	0.47
9/4/98	590	2.2	0.46
9/5/98	582	2.1	0.44
9/6/98	571	2.0	0.42
9/7/98	551	1.9	0.41
9/8/98	522	1.8	0.39

WY 97 Crows Landing 4-day running average continued:

Date	EC mmhos/cm	Se mg/L	B mg/L
9/9/98	501	1.9	0.37
9/10/98	492	1.8	0.36
9/11/98	499	1.8	0.36
9/12/98	518	1.9	0.37
9/13/98	528	1.9	0.38
9/14/98	526	1.9	0.39
9/15/98	511	2.0	0.39
9/16/98	486	1.9	0.37
9/17/98	465	1.9	0.36
9/18/98	450	1.9	0.35
9/19/98	430	1.8	0.32
9/20/98	411	1.8	0.31
9/21/98	392	1.4	0.29
9/22/98	387	1.2	0.28
9/23/98	401	1.1	0.28
9/24/98	414	0.9	0.28
9/25/98	431	1.0	0.29
9/26/98	439	1.0	0.30
9/27/98	421	0.9	0.28
9/28/98	397	0.7	0.27
9/29/98	385	0.6	0.26
9/30/98	374	0.6	0.25

Appendix D
San Joaquin River Hydrology-- Merced River to Patterson
Water Year 1998

Preliminary evaluation of discharge data for the lower San Joaquin River Basin revealed possible problems with Crows Landing data. Initial review of discharge data for this site resulted in adjustment by the USGS of the flow estimates for the months of March through July. Continued investigation into these revised discharges suggested that this revised discharge data might still be an overestimate of actual discharge. Discharge data for the Tuolumne River at Modesto, the Stanislaus River at Ripon, the San Joaquin River (SJR) near Vernalis, and the USGS revised discharge data for the SJR at Crows Landing are shown in Table D-1.

Discharge for the SJR near Vernalis during high flow periods, such as Water Year 1998, should generally be higher than the sum of discharge for the other sites because of accretions downstream of Crows Landing. The negative difference of Vernalis minus the sum of Crows Landing plus the Tuolumne plus the Stanislaus, during the months of January, February, and June, suggests that discharge at one of these sites is incorrect. A similar analysis, using DWR flow data for the SJR near Patterson (Ernie Taylor, personal communication) instead of Crows Landing flow data, shows no negative differences (Table D-2). DWR flow estimates for Patterson are lower than USGS estimates for Crows Landing from January through June 1998 (Table D-3). The SJR near Patterson is nine miles downstream of Crows Landing and there are no major inflows or outflows between the sites. These data suggest that Crows Landing discharge was likely overestimated for January, February, June, and perhaps other months. An attempt was made to quantify this overestimate and arrive at a most likely record of discharge for the SJR at Crows Landing by analyzing the flow records at these and several additional sites.

Table D-1 Monthly Discharge Data for Lower San Joaquin River Basin Sites- Crows Landing Data

Month	Crows Landing Flow (taf)	Tuolumne River* Flow (taf)	Stanislaus River* Flow (taf)	Sum of Crows Lndg + Tuol. R. + Stan. R. Flow (taf)	Vernalis Flow (taf)	Vernalis - Sum Flow (taf)
Oct	40	45	51	136	166	31
Nov	45	29	24	98	118	20
Dec	53	28	25	106	130	24
Jan	140	167	71	377	370	-7
Feb	1,001	417	234	1,652	1,561	-90
Mar	623	348	150	1,121	1,190	68
Apr	832	343	118	1,292	1,305	13
May	743	224	127	1,094	1,103	9
Jun	707	266	111	1,084	1,057	-27
Jul	503	184	115	801	811	10
Aug	108	74	110	293	335	42
Sep	110	97	101	308	343	34
WY Total	4,904	2,222	1,237	8,363	8,489	126

* USGS sites on the Tuolumne River at Modesto and the Stanislaus River at Ripon (based on data from H. Miyashita, USGS, 1999)
taf = thousand acre-feet
Shaded areas show months during which reported discharge is higher upstream than downstream

Table D-2
Monthly Discharge Data for Lower San Joaquin River Basin Sites- Patterson Data

Month	Patterson Flow (taf)	Tuolumne River* Flow (taf)	Stanislaus River* Flow (taf)	Sum of Patterson + Tuol. R. + Stan. R. Flow (taf)	Vernalis Flow (taf)	Vernalis - Sum Flow (taf)
Oct	47	45	51	143	166	24
Nov	55	29	24	108	118	10
Dec	63	28	25	116	130	15
Jan	130	167	71	367	370	3
Feb	790	417	234	1,441	1,561	120
Mar	608	348	150	1,107	1,190	83
Apr	795	343	118	1,256	1,305	49
May	705	224	127	1,056	1,103	47
Jun	668	266	111	1,045	1,057	12
Jul	529	184	115	827	811	-16
Aug	127	74	110	311	335	23
Sep	112	97	101	311	343	32
WY Total	4,629	2,222	1,237	8,088	8,489	-401

* USGS sites on the Tuolumne River at Modesto and the Stanislaus River at Ripon (based on data from H. Miyashita, USGS, 1999)
taf = thousand acre-feet
Shaded areas show months during which reported discharge is higher upstream than downstream

Table D-3. Crows Landing and Patterson Comparison of Discharge

Month	Crows Landing Flow (taf)	Patterson Flow (taf)	Patterson minus Crows Landing Flow (taf)
Oct	40	47	7
Nov	45	55	10
Dec	53	63	10
Jan	140	130	-10
Feb	1,001	790	-210
Mar	623	608	-15
Apr	832	795	-37
May	743	705	-38
Jun	707	668	-39
Jul	503	529	26
Aug	108	127	19
Sep	110	112	2
WY Total	4,904	4,629	-275

taf = thousand acre-feet

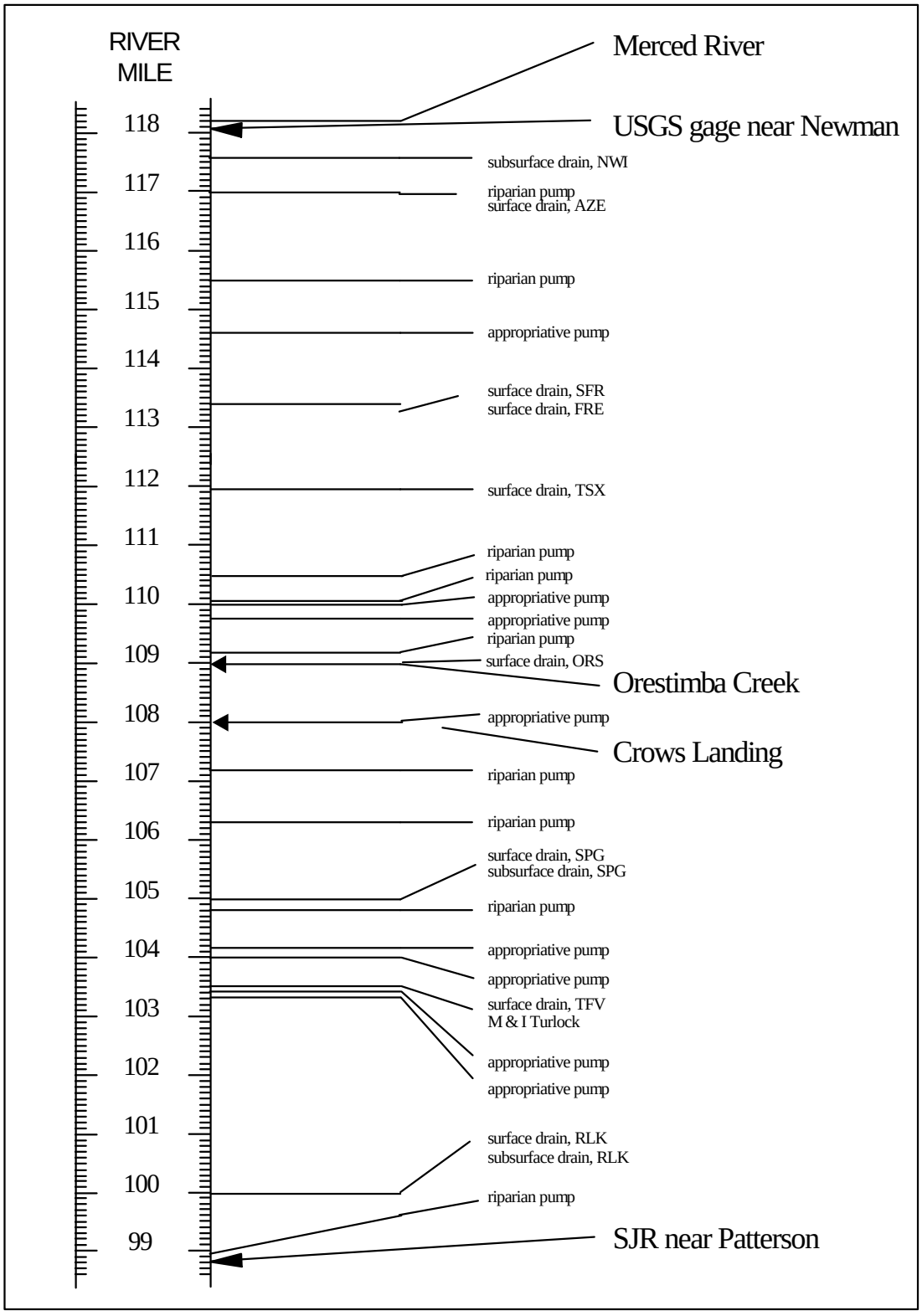
Major and minor features of the San Joaquin River, between the confluence of the Merced River and the SJR near Patterson, are shown in Figure D-1. The USGS gage for the SJR near Newman is just downstream of the Merced River confluence. The USGS site at Crows Landing is ten miles downstream of the Merced River, just downstream of the Orestimba Creek confluence. Aside from Orestimba Creek, sources of discharge for this reach of river include several agricultural drains, groundwater accretions, local rainfall, and runoff. Losses can be attributed to several agricultural water diversions, groundwater depletions, and evaporation. The SJR near Patterson gage is nine miles downstream of Crows Landing. The reach of river from Crows Landing to Patterson has several agricultural drains and diversions and a municipal discharge. The drainage area for the SJR near Newman is 9,520 square miles. The Orestimba Creek drainage area is 134 square miles at I-5 and indeterminate at River Road just upstream of the confluence with the SJR. The drainage area between River Road and I-5 is indeterminate because of the shifting drainage area in the lower valley attributable to agricultural practices. The drainage area for the SJR at Crows Landing is 9,694 square miles, only 40 square miles larger than the total reported for the SJR near Newman and Orestimba Creek.

Gains and losses from agricultural return flows and diversions are minimal in the winter months because of limited agricultural activity. During the irrigation months of March through August, the mean monthly rate of agricultural return flows for the SJR between Newman and Crows Landing is approximately 310 cfs (Kratzer et al, 1987). The mean monthly rate of agricultural diversion is approximately 60 cfs, resulting in mean monthly accretions of 250 cfs. Groundwater studies in the area (USGS, 1991) suggest a maximum rate of groundwater accretions on the order of 7 cfs per river mile for a total of 70 cfs for this ten-mile reach. Local runoff from rainfall is minimal at all times because levees on both banks of the river restrict local inflows to the areas inside the levees. Any gains from local rainfall and runoff via agricultural drains would be limited to time periods directly following rainfall events. An inch of runoff per month from one square mile draining to the river would account for a mean monthly increase of less than 1 cfs. Assuming a drainage area of 100 square miles on the east and west side of the SJR (2.5 times the reported difference of 40 square miles), one inch of runoff would account for a mean monthly increase of 88cfs. Table D-4 shows the mean monthly rainfall for four sites in the San Joaquin Valley; two on the east side and to on the west side (DWR California Data Exchange Center, 1999). Assuming all the rainfall from 100 square miles drains to the SJR, this rainfall would account for a maximum of 746 cfs in February, 302 cfs in May, and less than 200 cfs in all other months from March through July.

Table D-4. Water Year 1998 Precipitation at Selected Stations

	Precipitation (inches)											
Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Tracy Carbona	0.1	3.0	1.2	3.3	7.0	1.3	1.3	2.7	0.2	0.0	0.0	4.1
Los Banos	0.1	2.7	2.3	3.4	8.1	2.1	1.2	3.9	0.4	0.0	0.0	0.0
Modesto Irrigation District	0.1	2.6	1.5	4.8	8.8	1.5	1.1	4.0	0.2	0.0	0.0	0.0
Stockton	0.4	5.0	3.0	6.1	10.1	2.6	1.7	3.2	0.2	0.0	0.0	0.1
Four Station Average	0.2	3.3	2.0	4.4	8.5	1.9	1.3	3.4	0.2	0.0	0.0	1.0
Estimated Runoff (cfs / month)*	15	292	176	388	746	165	117	302	22	0	0	92
*Assumptions:	100	square mile drainage area										
	0.88	cfs/inch precipitation/square miles										
Data obtained from DWR California Data Exchange Center, 1999												

Figure D-1. Schematic of San Joaquin River, Merced River to Patterson



This analysis suggests that the net accretions of agricultural return flows, agricultural diversions, groundwater accretions, and rainfall to the SJR between Newman and Crows Landing should be no more than 820 cfs in February, 470 cfs in both March and April, 620 cfs in May, and 340 cfs in June through August. This is in contrast to the additional flows inferred by the Crows Landing data of 4,000 cfs in February, 1,000 to 2,000 cfs from March through August.

USGS reported discharge for Crows Landing was significantly higher than the reported discharge for the SJR near Newman plus Orestimba or the SJR near Patterson (Figure D-2a). Crows Landing minus the sum of Newman and Orestimba was 4,000 to 5,000 cfs in early February and continued to fluctuate between 1,000 and 2,000 cfs through August (Figure D-2b). Although higher discharge at a downstream site is consistent with a gaining stream with accretions from rainfall runoff, agricultural return flows, and groundwater, the magnitude of this is suspect, particularly during February. DWR data for the SJR near Patterson suggests a different pattern (Figure D-2c). This figure shows consistent, slightly higher discharge at Patterson than for the combined Newman and Orestimba for the fall months from September through December. The period from January through July shows widely fluctuating positive and negative values from -3,000 to 3,000. This graphic demonstrates the limits of resolution for correctly estimating discharge in this reach of river during high flow periods. During periods of high flow (greater than 10,000 cfs), flow estimates can easily be off by more than ten percent. The USGS has rated flow estimates for Crows Landing poor during high flow periods, meaning that flow estimates differ from actual by more than 15 percent (Jerry Smithson, USGS, 1999 personal communication). The data in Figure D-2c, for Patterson minus (Newman plus Orestimba), shows both positive and negative values, suggesting that there are no consistent errors for either of these sites. Figure D-2b, for Crows Landing minus (Newman plus Orestimba), suggests that there was a consistent overestimate of Crows Landing discharge, relative to Newman plus Orestimba, during high flow periods from February through July. The preceding arguments are used as the basis for reporting Water Year 1998 loads for Crows Landing using the sum of Newman and Orestimba Creek discharge for these high flow periods.

The preceding arguments also suggest that the sum of Newman and Orestimba Creek may represent a slight underestimate of the actual loads in the SJR at Crows Landing. Discharge, load, and concentration data, based only on unadjusted Crows Landing discharge, is therefore presented in Table D-5. Discharge and loads of all constituents are higher for the unadjusted Crows Landing discharge data than for the adjusted discharge data presented in the main body of the report (Table 10). Total selenium load for Water Year 1998, based upon unadjusted Crows Landing discharge data, was 15,130 pounds. This is 6,180 pounds more than the load estimated for the Grassland Watershed and 680 pounds less than the load estimated for Vernalis. Crows Landing selenium loads reported in table 12a are 3,815 pounds higher than the load estimated for the Grassland Watershed and 2,365 pounds less than the load estimated for Vernalis, suggesting that the source of the additional selenium is more evenly distributed in the lower San Joaquin River basin.

Figure D-2. Comparison of Discharge

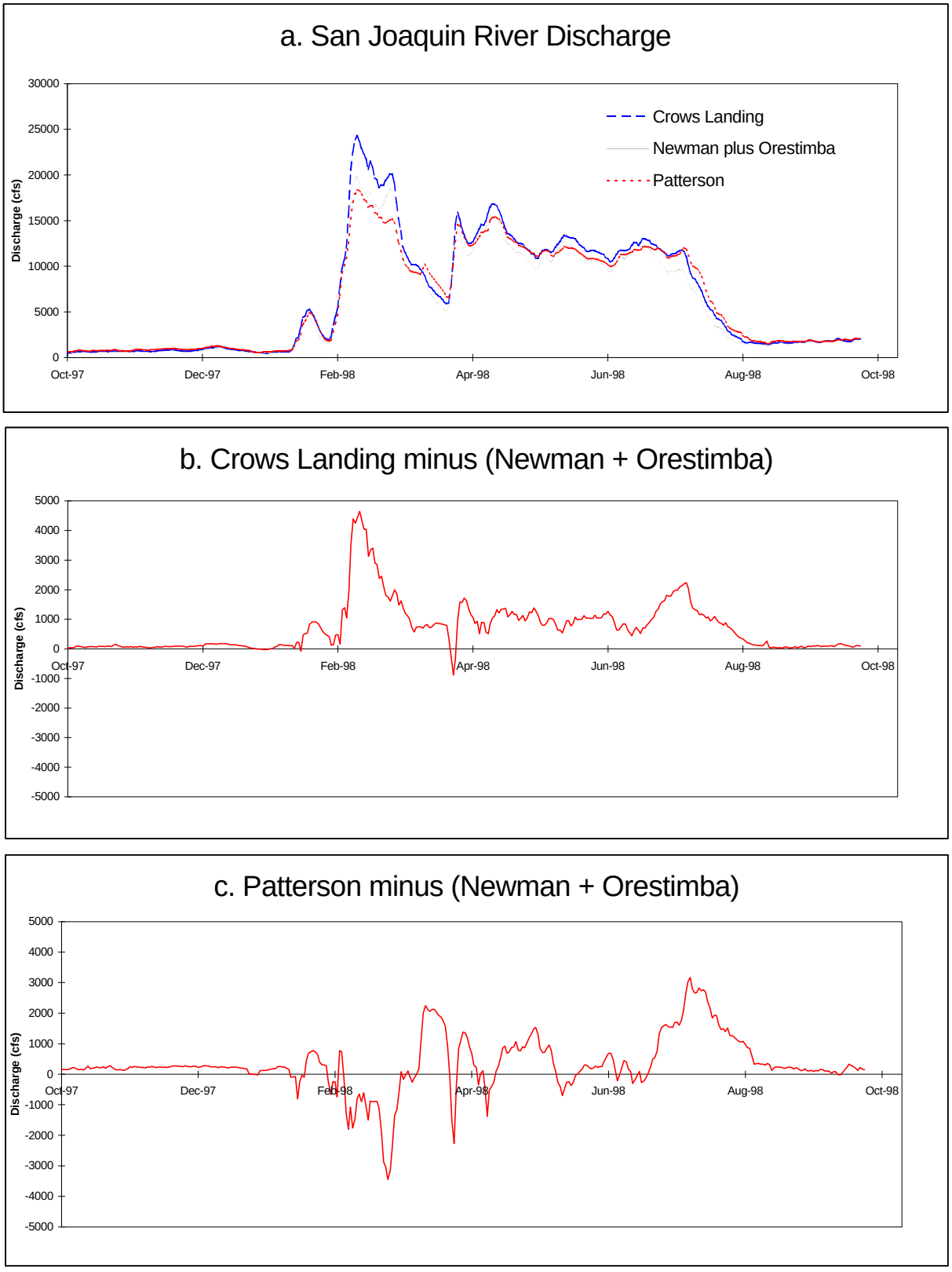


Table D-5. Uncorrected Crows Landing Discharge, Loads, and Flow Weighted Concentrations

for Water Year 1998

Month	Flow (taf)	Loads			Flow Weighted Concentration		
		Se (lbs)	B (1000 lbs)	TDS (1000 tons)	Se (ìg/L)	B (mg/L)	TDS (mg/L)
Oct	40	282	84	35	2.6	0.8	643
Nov	45	259	100	49	2.1	0.8	806
Dec	53	269	140	61	1.9	1.0	838
Jan	140	482	190	81	1.3	0.5	425
Feb	1,001	3,140	660	360	1.2	0.2	265
Mar	623	2,740	600	267	1.6	0.4	315
Apr	832	2,310	430	238	1.0	0.2	210
May	743	2,310	290	153	1.1	0.1	151
Jun	707	1,280	180	109	0.7	0.1	114
Jul	503	983	170	69	0.7	0.1	101
Aug	108	624	150	47	2.1	0.5	321
Sep	110	454	100	42	1.5	0.3	284
WY Total	4,904	15,130	3,090	1,511	1.1	0.2	227